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CONTENTS

	Page
Development of Atomic Energy in Britain	459
S. P. Timoshenko. By Sir Richard Southwell, F.R.S.	462
Introduction to Pile Neutron Research. By P. A. Egelstaff	462
Inorganic Chemical Analysis. By C. O Harvey	463
A Manual of Scientific and Industrial Instruments. By Dr. C. A. Taylor	464
The Process of Song-Learning in the Chaffinch as studied by means of the Sound Spectrograph. By Dr. W. H. Thorpe, F.R.S.	465
Excited Nucleons. By Prof. C. F. Powell, F.R.S.	469
Obituaries:	
Mr. Albert Campbell. By Dr. L. Hartshorn	472
Prof. D. S. Belyankin. By Dr. S. I. Tomkeieff	472
Prof. Giorgio Valle. By Dr. A. von Engel	472
News and Views	473
Atomic Weapons	477
Management of Public Corporations	477
Laboratory Animals Bureau. Dr. G. Lapage	480
Population of London, 1951	480
Flax in New Zealand. By Dr. A. J. Turner, C.B.E.	481
Botanical Historiography	482
Generation of Radio Noise by Cosmic Sources. By Dr. J. H. Piddington; F. Hoyle	482
Letters to the Editors:	
Phototropy of Chlorophyll Solutions.—Robert Livingston, George Porter and Maurice Windsor	485
Filter-Paper Chromatographic Analyses of Phosphate Mixtures.—Joan Pedley Crowther	486
Electrophoresis of Group-Specific Extracts of Streptococci.—Dr. N. J. Berridge and C. A. E. Briggs	486
Paper Electrophoresis of the Oligosaccharides synthesized from Sucrose by Yeast Invertase.—Dr. D. Gross	487
Thiaminase from Fresh-Water, Brackish-Water and Salt-Water Fish—S. T. Deolalkar and Prof. Kamala Sohonie	489
Free Amino-Acids in the Yolk during the Development of the Chick.—Matthew A. Williams, William A. DaCosta, Lloyd H. Newman and Lawrence M. Marshall	490
Waste of Carbon and of Energy in Nitrogen Excretion.—Dr. R. L. C. Pilgrim	491
Stimulation of Certain Bacteria by Raw Milk.—J. E. Auclair	491
Separation of Pigment Cells of Cacao.—Dr. H. B. Brown	492
Intra-arterial Injection of Methylene Blue for Staining Nerve Endings in Striated Muscles.—Kwok-Kew Cheng	492
Conductivities of Polyelectrolyte Solutions at High Frequencies.—C. S. Chadwick and Dr. S. M. Neale	493
Thermal Conductivity Measurements on Inert Media using Internal Calorimetry.—A. L. Haigh	493
Energy Requirements for Ion Transport in Steady-State Systems.—R. Whittam and Dr. R. E. Davies	494
Vibrations as a Cause of Disintegration in Liquid Sheets.—R. P. Fraser, O.B.E., N. Dombrowski and P. Eisenklam	495
High-Voltage Arcs in Argon–Nitrogen Mixtures.—R. W. Nicholls	495
Transmission of Electrons and Holes Across a Twin Boundary in Germanium.—Dr. E. Billig and M. S. Ridout	496
Fatigue Strength of Pure Tin at Room Temperature.—Dr. E. C. Ellwood and R. Duckett	497
Graphite Lubrication in Grey Cast Iron.—Prof. E. Knuth-Winterfeldt and E. Langer	497
Very Long Sequences of Geomagnetic Activity and its Annual Variation.—B. N. Bhargava and Ali M. Naqvi	498
Size of Fragments resulting from Tidal Disintegration.—(The late) P. S. Palmer	499
Processes controlling Zygophore Formation and Zygotropism in *Mucor mucedo* Brefeld.—G. H. Banbury	499
Nematode-destroying Fungi in Agricultural Soils.—Dr. C. L. Duddington	500
Demonstration of a Diffusible Fruiting Factor in Myxobacteria.—M. Lev	501
Delay of Chromosome Rejoining in *Vicia faba* induced by Irradiation.—Sheldon Wolff	501
Hydrostatic Pressure-Deficiency and the Emergence of Larvæ from Cysts of the Beet Eelworm.—H. R. Wallace	502
Hardness of Arthropod Mouthparts.—S. W. Bailey	503
Effect of Refrigeration of the Pupæ of *Microbracon brevicornis* Wesm. on the Pigmentation of the Adult.—E. S. Narayanan, G. W. Angalet, B. R. Subba Rao and G. I. D'Souza	503
Culture of Insect Tissues.—A. J. P. Goodchild	504
Occurrence of *Puccinia polysora* Underwood in the Indian Ocean Area.—G. Orian	505
Geographical Distribution of Mating Types in *Gibberella cyanogena* (Desm.) Sacc.—Dr. W. L. Gordon	505
Microflora of Crêpe Rubber—J. N. Turner and M. E. Kennedy	506
Poetry and Science.—Prof. H. Levy	506

DEVELOPMENT OF ATOMIC ENERGY IN BRITAIN

THE Atomic Energy Authority Bill follows the lines foreshadowed in the White Paper and in the long statement of the Government's policy which Lord Salisbury made on December 14. The Authority will consist of a chairman and not less than six or more than ten members, all appointed by the Lord President of the Council, whose responsibilities in regard to the Authority are clearly defined, and three of the members are to be persons with wide experience and proved capacity in dealing with problems associated with atomic energy. From the appointed day the Authority will be empowered to produce, use and dispose of atomic energy and to carry out research into any related subject, as well as to manufacture or handle other products required for such purposes. It will also arrange with universities and other institutions or persons for the conduct of research in atomic energy or radioactive substances, and with the approval of the Lord President of the Council and the Treasury, make grants or loans for production or research into matters connected with atomic energy or radioactive substances. Moreover, though the Authority is not, save under arrangement with the Minister of Supply, to develop or produce weapons or parts of weapons, it is explicitly free to conduct experimental work which may lead to improved types of explosive nuclear assemblies for atomic weapons.

The Authority is further empowered to distribute information relating to, and to train persons in, matters connected with atomic energy or radioactive substances. This clause to some extent appears to contemplate the Authority functioning as a training ground for the technical experts which industry will require when the industrial application of nuclear power becomes imminent. Apart from this, although the Authority to be established by the Bill is very clearly a manufacturing organization, with a degree of autonomy at least comparable to that enjoyed by other public corporations, and very considerable powers of direction for the technologists, and not as the Atomic Energy Commission of the United States, a co-ordinating body, the Bill makes even less reference to the co-operation of industry than did the White Paper. There appears to be no intention of permitting private industry to gain the all-important experience of helping with the design or operating of the key industrial plants which the Authority will control.

It would appear to fall within the powers and duties of the Lord President of the Council to give appropriate directions if at any time they should be deemed desirable. The Atomic Energy Act, 1946, already places on the Lord President the general duty of promoting and controlling the development of atomic energy, and the present Bill specifies that this duty shall include that of seeing that the Authority attaches the proper degrees of importance to the various applications of atomic energy. The Lord President may give general or particular directions after consultation with the Authority, but

is not expected to interfere in detail unless in his opinion over-riding national interests necessitate intervention. Furthermore, the powers of the Lord President, as defined in this section of the Bill, place on him the ultimate responsibility for deciding how wide and effective public discussion in this field can be by the extent to which he permits publication of the Authority's annual report.

That much was confirmed by the Minister of Works, Sir David Eccles, in moving the second reading of the Bill in the House of Commons on March 1. Sir David also referred particularly to the transfer proposed in the Bill of the powers in the Atomic Energy Act, 1946, and the Radioactive Substances Act, 1948, which relates to research, development and disposal of radioactive substances, from the Lord President to the Atomic Energy Authority. This step followed the transfer of Ministerial responsibility for atomic energy from the Minister of Supply to the Lord President of the Council, to which Parliament agreed last December. Sir David also indicated that the Lord President proposed to invite Sir John Cockcroft, Sir Christopher Hinton and Sir William Penney to be founder-members of the Authority, while continuing their executive responsibilities in sections of the Authority's work. He also stated that it had been decided to build a big, fast reactor of the 'breeder' type at Dounreay in Caithness, where survey work had already begun.

The magnitude of the responsibilities for Government policy in scientific and technological matters is made unmistakable by the Bill. Whether in fact they make impossible demands upon any one man, with his office as at present constituted, may be open to discussion. It should at least be impossible for the Lord President ever again to be saddled with extraneous departmental responsibilities, even through Ministerial sickness, and the practicability of the co-ordination of our scientific and technological effort and the disposition of the immense material resources involved in the organizations for which he is now responsible should be a central point in Parliamentary discussions on the Bill. Experience may well show whether or not some of the details of the proposed arrangements are sound, nor should it be difficult to modify them if necessary. What is all-important is effective informed public discussion of the fundamental issues involved in committing our resources on this scale.

Within the limits possible, the Atomic Scientists' Association has done much in recent months to bring to public discussion some of those questions. Others have been discussed in the United States in a series of issues of the *Bulletin of the Atomic Scientists*, which in the past year has repeatedly examined not only the security issue and its implications but also the place of private enterprise in the development of atomic energy. The Atomic Energy Commission in the United States has in fact already committed itself to the greater participation of industry, even to the extent of ownership and operation of nuclear power units and a more liberal policy in regard to patent rights. A recent (November 1953) issue of the *Annals of the American Academy of Political and Social Science* also explores in a series of articles not only such issues but also other implications of the impact of atomic energy, in the political and the industrial fields and on society in general.

The changes now proposed for Great Britain require, indeed, consideration in the widest context, not only in the light of the implications for our scientific and technical effort and resources, whether of man-power or materials, but also in the light of the effects upon our political institutions and the whole structure of society. It is perhaps even yet not fully appreciated how far secrecy has undermined the functioning of the democratic institutions by hindering the process of public understanding and control. The Government's decision to join the European Nuclear Research Organization is clearly right, as Lord Salisbury said at the anniversary dinner of the Royal Society, but less for the possibility of economy of material resources in such research, to which Lord Salisbury referred, than for the reason indicated by Dr. E. D. Adrian—the prospect of a speedier contraction of the area of secrecy.

The whole trend of Sir David Eccles's speech suggests that the Government is well aware of the importance of extending the area of public discussion as far as possible. There was no need, he said, to develop the peaceful uses of fissile material in the dark. It was intended that the Authority should have more liberty to let the outside world know what it was doing. Parliament and industry ought now to know what was going on, and, while he stressed the need for a strict security system, it was in the context that, unless there was mutual confidence in the effectiveness of security systems which guard information of such value to a potential enemy, we could not expect the essential exchange of information on the knowledge and practice of atomic weapons between members of the North Atlantic Treaty Organization. The finance of atomic energy, he admitted, was bound to be a trifle unruly and it was particularly difficult to estimate in advance how much new development would cost in any one financial year.

It should at least be recognized that the change now proposed will for the first time give Parliament some idea of the magnitude of expenditure in this field. According to Sir David, over the six years 1946–51, this exceeded £100 millions, and the Vote on Account now gives it as more than £50 millions a year, a figure which Sir David said would rise. Furthermore, although the proposals as set forth in the White Paper and in the Bill are open to the criticism that they give little indication as to how the all-important close contact and co-operation with industry are to be fostered, Sir David emphasized the Government's intention that, when a civil application of atomic energy reached the commercial stage, industry should take over, and he regarded expansion on the industrial side as a conclusive argument for the organization outside the Civil Service now proposed. Only under such an organization as is now proposed could we

hope to secure the drive and initiative, the speed and flexibility which would enable our scientists and engineers to develop fully this new source of power.

This vital factor of speed and initiative was missed by Opposition speakers in the debate, who seemed more intent on scoring party points than on constructive criticism or hammering out an agreed policy from the fundamental issues. Nor did two further important points made by Sir David receive comment. Referring to the placing of research contracts with universities and with industry, he said that the Authority would consider the education of outside scientists and engineers to be a very important part of its task. Further, following the example of the United States Atomic Energy Commission, a school of reactor technology was being set up where engineers from industry could learn about the fundamental principles of reactor design and be brought up against the many technical problems which designers have to solve.

The Government would do well to consider how far it can go within the framework envisaged by the White Paper, to make arrangements which will encourage confidence and facilitate discussion over the widest possible area of the scientific and technological effort of Great Britain. Something, of course, will depend on the appointments made to the additional posts to be created.

There are many problems on which no doubt the Government, and possibly the Waverley Committee itself, has reached no decision, and some may require time for solution. Some at least will be solved more readily by public discussion, and the Government should make it clear that there is to be no secrecy for secrecy's sake, even if in some matters care must be taken not to prejudice the fairer prospects for the Anglo-American exchange of information on atomic energy or other possibilities of Anglo-American co-operation. Neither science nor industry, however, must be held at arm's length. Frankness and confidence and full discussion within the practicable limits, generously interpreted, are the surest means of securing the co-operation of industry and of science, as they are of recruiting to the service of the Authority men of the ability and integrity required to discharge its great responsibilities with vision and energy, and to operate with skill, resource and decision.

There is this much to be added. The decision, for which there is a large measure of political agreement, to transfer to a public corporation the responsibility for the development of atomic energy must not be taken to imply that Britain is about to enjoy the benefits of nuclear fission, either for the production of power or for those other industrial purposes at which Sir John Cockcroft hinted in his Dalton Lecture on November 27. Even if the present hopes of the thermal reactors and the breeder reactor are fully realized, the application of nuclear power is still highly speculative, and much research and objective thought will be required if it is to bring advantage even to a nation placed such as Britain is in regard to fuel supplies. Isard and Whitney's recent study, while disposing of some exaggerated ideas of the benefits which nuclear power could bring to underdeveloped areas lacking in power resources, and of the industrial disturbance likely to be caused by the adoption of nuclear energy as a source of power, left no doubt that the right decisions should be made objectively and on a factual basis*.

Their argument receives powerful support in the papers on the economic or sociological consequences of nuclear power and those on human values in the atomic age contributed to the symposium of the American Academy of Political and Social Science (*Annals*, **290**; Nov. 1953), while the danger of allowing the development of atomic energy to become a party political issue can be seen in a paper by E. Douvan and S. B. Withey in the same symposium. To urge that the development of atomic energy should not be allowed to become a political issue, because there is considerable agreement that it should be entrusted to a public body subject only to broad Government control of policy and objectives, is not to suggest that the details of organization or of accountability have yet been settled, let alone agreed. It is rather to urge that those details, and above all the question of accountability, are most likely to find a satisfactory solution through an impartial, objective, all-party approach such as characterized the last debate on the nationalized industries in the House of Commons. An agreed solution of this vital question of accountability on such lines would have decisive advantages. It would give the proposed Corporation a standing which would command the confidence alike of scientist and technologist of the highest ability, whose services the Corporation must seek to enlist, and of industrial firms of repute and resources to which the Corporation could wisely entrust the development of reactors or fission products. It would, by removing the temptation to make party political capital out of minor points of difference over organization, and encouraging confidence in the effectiveness of public accountability, help any Government in power, independent of its political character, to maintain the wide and steady support from public funds which any enterprise of this kind requires before any return can be expected. Further, the support demanded for effective return, whether in defence or elsewhere, is on a scale which may well restrict the resources which can be apportioned to the social services or other sections of the national economy. The Government clearly can lead the way by making the area of public discussion as wide as possible, and putting the narrowest limits on secrecy that a realistic view of security permits; and the Opposition must respond in order to take the whole question out of the arena of politics. Grave indeed will be the responsibility of any who hinder accord and disturb the process of critical but objective inquiry and mutual understanding, upon which depend the ability of the new Corporation to recruit staff of the requisite calibre, to secure the co-operation of responsible industry and to provide the nation with whatever benefits the application of nuclear energy or fission products can bring.

* "Atomic Power." By Walter Isard and Vincent Whitney. Pp. xi+235. (London: George Allen and Unwin, Ltd., 1952.) 37*s.* 6*d.* net.

S. P. TIMOSHENKO

The Collected Papers of Stephen P. Timoshenko
Pp. xxv+642. (London: McGraw-Hill Publishing Company, Ltd., 1953.) 140*s*.

History of Strength of Materials
With a brief account of the History of Theory of Elasticity and Theory of Structures. By Prof. Stephen P. Timoshenko. Pp. x+452. (London: McGraw-Hill Publishing Company, Ltd., 1953.) 71*s*. 6*d*.

STEPHEN PROKOFIEVITCH TIMOSHENKO was born on December 22, 1878. Few men have suffered more interruption of their scientific work by war and revolution, yet few have had greater influence or, when they attained the age of seventy-five, a wider circle of devoted friends to join in birthday greetings. Six who have been associated with him longest have produced, to celebrate the anniversary, a volume containing all his papers except a few in Russian never republished elsewhere, along with an admirable photograph and a biographical preface. It appears almost simultaneously (and in identical format) with his own monumental "History of Strength of Materials": an amplification of lectures given in the past twenty-five years, of which the first chapter starts from the birth of Galileo, the last takes the story down to 1950. Together the books comprise more than a thousand pages—too much material for a detailed review.

By his friends they will be studied in conjunction, for the light they throw on the development of his thought; more particularly the last two chapters of the "History", in conjunction with Prof. D. H. Young's "short biographical sketch". They cover the first half of the present century: years in which Klein, Runge, Prandtl and von Kármán increased yet further the fame that Gauss, Dirichlet, Riemann and Clebsch had brought to the University of Göttingen. It was there, in 1905, that Timoshenko met Klein's innovation of seminars attended both by engineers and mathematicians; there, that at the suggestion of Ludwig Prandtl he began the study of what has been his prime interest ever since—the theory of elastic instability. As it happened, in the two preceding years he had read Love's "Elasticity" and Rayleigh's "Sound" ("Such was the subject-matter by which he taught himself to read English"), and his first paper, published in 1905 (in Russian), reveals the immense impression Rayleigh's work had made on him. In it—for the first time, probably—a man discussed elastic instability who realized that 'Rayleigh's method', though propounded in relation to vibrating systems, is applicable to physically distinct problems. Somewhat later (1909) Ritz had extended it by largely increasing the number of the variable parameters; and his work, too, made a great impression on Timoshenko, shown by the reference to it in the French version (1913) of his big memoir of 1910 (in German)—so great an impression, that almost invariably he has termed the extended method the 'method of Rayleigh–Ritz'. It may well be that Ritz hit on it independently, for his first paper called it a "new method for the solution of variational problems"; but I confess to being, with Rayleigh ("Collected Papers", **6**, p. 48), "surprised that he should have regarded the method itself as new. . . .". (Referring to his own "Theory of Sound", Rayleigh continued: "I had supposed that this treatise abounded in applications of the method . . ."; and added, "in a more recent paper [1899] . . . it takes almost exactly the shape employed by Ritz".)

For me it has been of absorbing interest to read of events preceding those of which I learned something at the time, in letters from Timoshenko relating to scientific publication. Though given an introduction in 1913 (by Bertram Hopkinson) I did not meet him in person until 1921; by then he had become a professor in Zagreb, and had sent me from there a paper which appeared in the *Philosophical Magazine* of May 1921. Other papers followed during 1922, in which year he passed through London on his way to his first post in the United States. He did not (I think) contribute to the First Congress of Applied Mechanics at Delft in 1924—the year in which his first book was published in the United States—but read two papers (both now reproduced) at the Second Congress in Zurich (1926). In 1927 he re-entered academic life as professor of graduate mechanics in the University of Michigan, and there began to exert on engineering education an influence which by now is quite unparalleled: by lectures, seminars and summer schools, and above all by the text-books which have made his fame world-wide.

They are used everywhere, and in large measure they remove the need for students to study his original papers; but all will turn to his "History" who have heard his lectures and recall their outstanding quality of erudition. For many books have been written on strength of materials, but few that show even an interest in the men that have developed it. Inevitably, in a work so comprehensive, some pronouncements will seem questionable, some omissions hard to understand; and I for one was surprised to find no account of work by Baker's school at Cambridge and Prager's at Brown University on 'limit design' of steel structures with rigid joints, no mention—in a survey which includes experiment—of Bridgman's work with very high pressures or of the work of Cook and Robertson which revealed, in mild steel, the 'drop of stress at yield'. But these are but incidental criticisms, and what remains from a reading as yet only cursory is delighted amazement at the sweep and vigour of one man's handling of so vast a theme. Many footnotes will need revision when the "History" has been assimilated.

R. V. Southwell

INTRODUCTION TO PILE NEUTRON RESEARCH

Pile Neutron Research
By Prof. D. J. Hughes. (Addison–Wesley Nuclear Science and Engineering Series.) Pp. xiii+386. (Cambridge, Mass.: Addison–Wesley Publishing Co., Inc., 1953.) 8.50 dollars.

THE first chain-reacting pile became critical in December 1942, and during the decade following that event the pile has been extensively used as a neutron source. A new technology has grown up with the development of 'pile neutron research', and as the numbers working in this field increase it has become a pressing need to have a basic text-book for the subject. This need is met by this book by Prof. D. J. Hughes. It is the nature—and the weakness—of the book to describe the work that has been done without reviewing it critically.

As is proper in dealing with a new subject, a great deal of the material is presented at an elementary

level, but in most cases references are given which would enable a particular subject to be taken further. The author classifies his material (apart from the chapters on neutron optics) according to the type of pile facility required, and this enables him to place the wide diversity of the objects of pile neutron experiments into reasonable order. Some of the illustrative experiments (for example, those on neutron mirrors) are given in great detail, presumably because this will familiarize the student with some of the difficulties of careful and accurate measurements with the pile. However, Prof. Hughes does not stress this point. It is inevitable that, as a new field is developed, systematic errors should be present in some of the early measurements because some of the factors which influence the results are overlooked. A striking illustration of this is the frequent disagreement of various cross-section measurements (for example, the total cross-sections of boron and gold). At the present stage in the development of this new technology, it is important that a very critical approach should be made to every measurement, and that normally the experimental error quoted should be treated with reserve. This point should have been emphasized throughout the book.

A good basic introduction to the neutron and to reactors is given in the first two chapters. A practical point of some importance which is not mentioned here is the movement of the flux distribution in the pile as the control rods are moved. This is one of the reasons why separate monitoring of the intensity in beam experiments is desirable. In Chapters 3–11 a complete account of the development of pile neutron research is found. Attention is focused upon the techniques rather than the theory, and for the latter the student is invited to study the references given. The point of interest is the behaviour of the neutrons of various velocity groups.

The principles behind most of the measurements are simple, but since it is difficult to obtain accurate results, it would have been useful (in a book on technology) if Prof. Hughes had listed the precautions which had been taken in each experiment.

Of the various points discussed, those worth emphasizing are the uncertainties in the absolute determination of neutron intensities and cross-sections, and of the detail of neutron spectra. In beam experiments one needs to have reliable collimation of fast and slow neutrons and γ-rays, and to control, by careful shielding, backgrounds due to multiple scattering of neutrons. Considerable space is devoted to the discussion of filters, which are finding increasing use as ancillaries in more complicated equipment.

Occasionally, in the interests of simplicity the subject has been over-simplified. For example, the thermal inelastic scattering is stated to be incoherent, whereas it exhibits (particularly in the energy spectrum of the scattered neutrons) pronounced interference effects. Or, again, in the discussion of the resolution of time-of-flight spectrometers, it is tacitly assumed that the time uncertainty of the instrument is a constant, whereas in many cases the time-of-flight in the detector is appreciable, and this contribution to the resolution width is a function of neutron velocity. This means that to the table of resolution widths (Table 6–2) a definite velocity should be assigned.

The book concludes with a chapter on health physics. In many cases the question of the health hazard involved in an experiment must fall upon the experimentalist, and it would be instructive to the student to read this chapter after Chapter 2 and before proceeding to the experimental sections. A useful course on pile physics and a table of thermal neutron cross-sections are found in appendixes.

In all the branches of the subject discussed by Prof. Hughes, rapid advances are being made and very soon new techniques will be in use. In spite of this, this book will remain for some years a valuable introductory text. Prof. Hughes is to be congratulated on writing with such lucidity and detail on the many and varied aspects of pile neutron research.

P. A. EGELSTAFF

INORGANIC CHEMICAL ANALYSIS

Textbook of Quantitative Inorganic Analysis

By Prof. I. M. Kolthoff and Prof. E. B. Sandell. Third edition. Pp. xv+759. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1952.) 30*s*. net.

Applied Inorganic Analysis

With Special Reference to the Analysis of Metals, Minerals and Rocks. By the late Dr. W. F. Hillebrand and the late Dr. G. E. F. Lundell. Second edition revised by Dr. G. E. F. Lundell, H. A. Bright, and Dr. J. I. Hoffman. Pp. xxii+1034. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1953.) 120*s*. net.

THOUGH there is some overlap, these two new editions of well-known books are complementary.

In this, the third edition of their book, Profs. I. M. Kolthoff and E. B. Sandell adhere to their original purpose and provide a detailed treatment of the theoretical and practical aspects of many gravimetric, volumetric and physicochemical methods of chemical analysis; more modern developments, such as chromatography, mass spectrometry, Raman spectroscopy, fluorescence and other topics are reviewed, with adequate references to more detailed expositions. The book is intended for university students, but more experienced workers will find in it a useful summary of recent developments. As a practical reference work for the advanced or specialized worker, the book is less useful; for example, the section on gravimetric determinations deals in detail with only water, chlorine, iron, aluminium, sulphur, calcium, magnesium, phosphorus, silica, sodium, potassium, copper, nickel and limestone. One hastens to add that sections on brass, steel and silicate rocks, and numerous bibliographical references, greatly extend the scope of the book, and that throughout, when details are given, the treatment is thorough. In this thoroughly revised and modernized edition, sections rewritten or enlarged include those dealing with physical and physicochemical methods and with organic reagents.

The first edition of W. F. Hillebrand and G. E. F. Lundell's "Applied Inorganic Analysis" was published in 1929; because of its excellence and very reputable authors, the book was accepted as a standard work of reference. Though the original authors are now dead, Dr. Lundell wrote much of this new edition; his manuscript was reviewed and completed after his death by the two junior authors. The general arrangement of subject-matter in the old and new editions is substantially the same, the aim being to describe useful methods of separation and determination rather than to catalogue all

available methods, some of which may be useless for the analysis of complex substances.

For each element or group of elements, information is given concerning behaviour during the course of an 'ordinary' analysis, methods of decomposing minerals, methods of separation and methods of determination. The book has been brought up to date by appropriate omissions, additions and rewriting; special methods, such as those involving the use of the spectrograph, the polarograph, etc., receive attention, but are not described in detail. Some information is given about nearly all the chemical elements, the only elements not included being inappropriate ones, that is, the rare gases, actinium, polonium and the elements discovered during recent years. The section on the rare-earth metals contains much useful information concerning the more orthodox methods, but ion-exchange methods are not described in detail; however, this section, like all sections of the book, is adequately annotated with references to other publications. Similar comments apply to other parts of the book; as examples, the dithizone method for lead, and ether-extraction methods for the separation of uranium are not described in detail. In this edition, the sections dealing with glass, bauxite and refractories have been omitted, but the classical methods used by Dr. Hillebrand for rock and mineral analysis are retained, with necessary additions.

C. O. Harvey

A MANUAL OF SCIENTIFIC AND INDUSTRIAL INSTRUMENTS

The Instrument Manual

Second edition. Pp. vii+628+105. (London: United Trade Press, Ltd., 1953.) 84*s*.

THE writing of an adverse review is always an unpleasant task, but the unpleasantness increases with the size and price of the book concerned; there seems to be an instinctive feeling that a large and expensive volume should be more reliable than a small, cheap one.

The second edition of the "Instrument Manual" is designed on a large and expensive scale; the idea behind it is excellent, but the result is sadly disappointing. The manual is divided into a series of chapters each of which deals with a particular type of measurement and consists of a theoretical introduction, descriptions of the instruments available, a list of manufacturers and a list of references to the literature. The field covered is very wide and the present reviewer can only comment with confidence on the detail of one or two of the chapters, but grossly misleading and erroneous statements found on familiar subjects undermine one's confidence in the remainder.

Perhaps examples from one of the more unfortunate sections might be quoted here (p. 56, Polarimetry): "Polarisation. To understand polarisation it is necessary to regard light as being a wave motion in more than one plane, e.g. there will be transverse vibrations as well as those in the direction of travel of the wave. The effect is indicated simply in Fig. OP 11. If it should be possible to remove one of these modes of vibration, the wave is said to have become plane polarised". The figure mentioned is said to represent a wave travelling along the *z*-axis of a system of co-ordinates and shows *two* sinusoidal waves, one along *z* and one along *y*, at right angles to it. Later in the paragraph we find the statement: "If *y* becomes zero, the wave can be said to be plane polarised . . .". Towards the end of the following section we read: "If the plane polarised light emerging from a Nicol prism is allowed to fall on a second prism with its principal plane parallel to the first, the beam is split into two components, one of which, as in the first Nicol, is transmitted. If the second prism is rotated, it will be found that the intensity of the light decreases to a minimum when the principal planes are crossed at an angle of 90°. The intensity is thus *proportional to the angle of rotation*" (the italics are the reviewer's). These statements surely need no comment.

In addition to serious errors of this type, the book contains a large number of paragraphs which give no useful information at all and which might very well mislead a person with no previous knowledge of the instrument described. An example of this is the description of wet- and dry-bulb thermometers on p. 531. It is quoted in full: "These are mercury-in-glass thermometers in which the bulb is circular, and consist of the normal thermometer stem encased in an outer glass sheath, terminating at its upper end in a glass button for suspension purposes. The sheath not only protects the graduation against damage but prevents the condensation of moisture on the divisions or figures of the scale. At the lower end it is fused to the thermometer proper between the bulb and the lowest graduation". Such a description would certainly merit no marks at all in an examination at even the lowest level.

Some of the sections seem to be incomplete and lack continuity, as though they had been made up by stringing together the work of different writers and draughtsmen without proper co-ordination. For example, in a section of the chapter on temperature measurement headed "Black Body Radiation" (which, incidentally, begins "If a piece of carbon or charcoal (i.e. a black body) . . .") we find a diagram (p. 277) of a square enclosure labelled *A* with a ray, starting from wall *C* and being regularly reflected in turn from walls *D*, *E* and *B*. The whole paragraph relating to this figure runs as follows: "Accepting a black body condition as standard, it is desirable to achieve this as nearly as possible in actual instrumentation. Let us consider in Fig. T.T. 64 an enclosure A at a uniform temperature with a very small opening at B. The walls of the enclosure are of a material which partially absorbs and reflects radiation. A ray starting from wall C strikes wall D. Corrections may be necessary because of temperature gradient in the tube".

It would not serve any useful purpose to give any more detailed examples. One might summarize by stating that the book is reminiscent of an examination script sent in by a reasonably good student who, in his anxiety to impress the examiner, has written down all he knows regardless of its relevance to the question, putting in padding where his knowledge fails, occasionally going off the rails altogether, and certainly leaving no time for reading through at the end. In the stress of an examination this could be forgiven, but one scarcely expects it in the second, revised edition of a book costing four guineas.

There is undoubtedly a need for a book covering this ground and a great opportunity has been missed. Let us hope that if a third edition should be contemplated, the attention of the editors will be concentrated on putting right what is already there rather than on the addition of new material.

C. A. Taylor

THE PROCESS OF SONG-LEARNING IN THE CHAFFINCH AS STUDIED BY MEANS OF THE SOUND SPECTROGRAPH

By Dr. W. H. THORPE, F.R.S.

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IT has been known since the late seventeenth century[1] that the full song of some species of passerine birds shows considerable local variation in pattern; and there are many facts which point to the conclusion that some of this local variation is the expression of a 'learned tradition' and not, as most call notes seem to be, genetically fixed. Nevertheless, there is also very strong evidence with many other species that even the full songs may be primarily an expression of genetic constitution. So we get the puzzling situation that complex details of the full song may be completely inborn in many species, modifiable by learning in some and probably entirely learnt in yet others[2]. It has been suggested that many of the apparently inborn 'recognitions'—as, for example, the visual recognition of the fellow member of the species—which play such an essential part in the organization of the social life of many animals are, in fact, acquired by a special type of learning known as imprinting, which is very rapid and the effects of which are extremely persistent. The process of song learning certainly resembles imprinting in several respects, and in any event the details of the interlacement of instinct and learning in situations such as that of song production are of interest from many points of view. This is especially true in that the restriction of learning ability to a particular period and particular circumstances is not a situation with which learning theorists are as yet very familiar; and indeed such a process raises interesting problems concerning the very nature of learning itself.

Until recently, it was scarcely possible to make much progress with the problem of song learning. Bird songs, like most other animal sounds, are difficult to describe in words, and even the most musical find it difficult to remember minute details of song without the aid of a suitable notation; so the dangers of subjective interpretation are always serious. But even if a satisfactory system of notation had been elaborated, there would still have remained the primary difficulty of perceiving accurately by the naked ear elaborate sound patterns of high frequency, high speed and rapid modulation. All this was changed, however, by the development on one hand of methods of high-fidelity 'electrical recording' on disk and of magnetic recording on tape, and on the other hand by the invention of the sound spectrograph, now known commercially as the 'Sonograph'. This latter instrument automatically provides a graphic analysis of complex sound signals that vary with time.

In operation, the sound which it is required to analyse is first recorded magnetically on the edge of a 12-in. metal disk. The disk is then revolved repeatedly at 3·3 times the recording speed, and at each repetition the signal is scanned by either a 45-cycle or a 300-cycle band-pass filter which is shifted slightly in frequency at each repetition. The output of the analysing filter is then recorded on dry facsimile paper on a drum which revolves synchronously with the magnetic disk. The recording stylus shifts gradually along the frequency-scale in step with the scanning oscillator, thus recording the frequency components at any given instant, while amplitude fluctuations will be represented by fluctuations of intensity at the output of the filter and so will show up on the paper as lighter or darker areas—the darker regions being those of higher energy-level.

From this graphic representation, frequency, amplitude and duration can be determined with sufficient accuracy, and moreover the sound spectrogram can with practice be recognized and interpreted as a 'picture' of the sounds. It thus supplies a form of notation as well as a method of precise measurement. So it is that an entirely new field in behaviour study has been opened up, for whereas vocalizations were formerly the most difficult of all releasers to investigate precisely, they have now become far more readily amenable to analysis than are many patterns of visual or olfactory stimulation. The object of the present article is to indicate some of the many possibilities of the method, and to give in preliminary outline some of the more important results so far achieved.

The method in the present study has been to record all the songs either on tape or disk, to subject them to rough preliminary 'inspection' by slowing down on re-play, and then to analyse them by transferring them to the sound spectrograph. The disk and tape machines used will deal faithfully with sounds from 50 to 12,000 cycles and from 50 to 17,000 cycles per second respectively, while the sonograph can also be adapted to deal directly or indirectly with the latter frequency-range. It has, in fact, transpired that for present purposes the range 2,000–10,000 cycles per sec. is all that need be taken into account. (For the first use of the 'Sonograph' I have been greatly indebted to the kindness and courtesy of the Superintendent and staff of the Admiralty Research Laboratory at Teddington, whose 'Sonograph' was for a long time the sole instrument of its kind in England. In particular, I would like to express my thanks to Mr. S. A. Byard and Mr. H. G. T. P. Rissoné. Latterly, through a generous benefaction, a new instrument has been provided specially for this and similar work at the Ornithological Field Station of the University of Cambridge Department of Zoology at Madingley. The sound spectrograms here reproduced have all been made with this new instrument.)

Work was commenced in 1950 with the inauguration of the above field station. Here was available for the first time the necessary equipment of breeding aviaries, bird-rooms for hand rearing and observa-

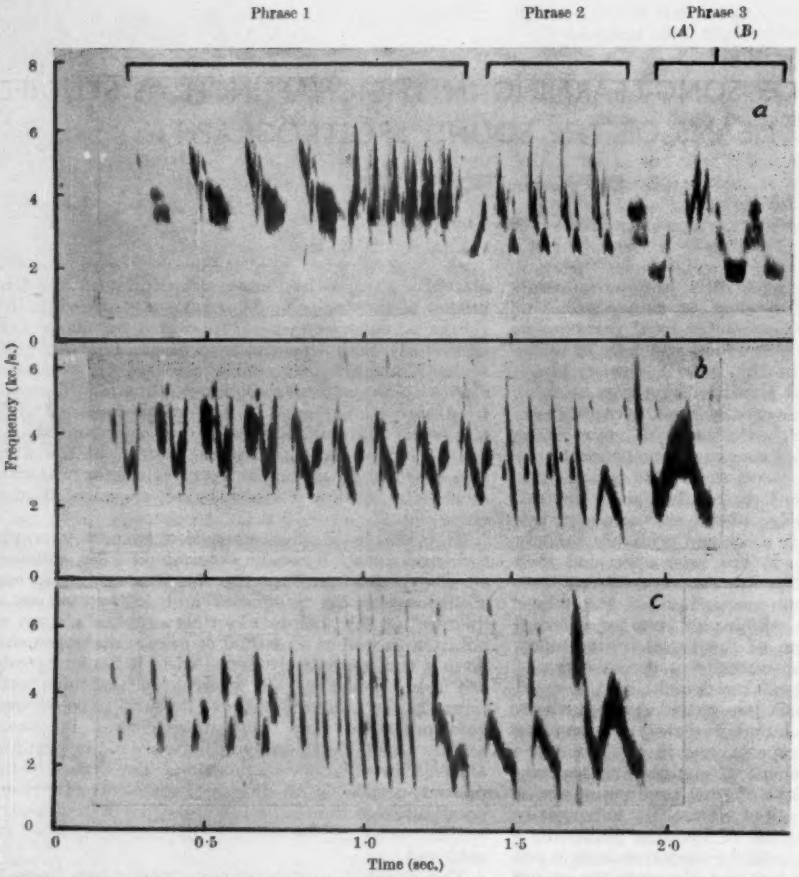

Fig. 1. Sound spectrograms of songs of control chaffinches in aviaries showing the three phrases. (*a*) *RWB*²/*W*, April 20, 1953. (*b*) *BW*/*W*, May 13, 1953. (*c*) *BtW*/*BtP*, March 25, 1953 Band-pass filter, 300 c./s.

tion, and sound-proof rooms for isolation experiments. The chaffinch (*Fringilla coelebs*) was chosen as the first and chief experimental species for several reasons: it has a complex and not too elaborate phrasical song of medium frequency-range and convenient length. Moreover, while the song is readily recognizable in its different forms, it is well known to have striking local peculiarities, songs of one type predominating in one area, those of another in an adjacent area[3]; and each individual normally sings only one type of song.

The normal chaffinch song, which is both a territorial proclamation and a stimulus to the female, consists of three phrases (Fig. 1). Phrase 1 consists of from four to fourteen notes, usually somewhat *crescendo* and normally with a gradual or step-wise decrease of mean frequency. This is followed by phrase 2, which is usually, but not always, distinct and is made up of a series of two to eight notes. These notes are of a fairly constant frequency, lower than that of phrase 1. The song concludes with a phrase 3 consisting of from one to five notes (phrase 3*A*), together with a more or less complex terminal flourish (phrase 3*B*).

In 1950 Poulsen[4] described how two male chaffinches reared in isolation had produced songs which were abnormal in the pitch and rhythm of phrases 1 and 2, and in having a single note in place of the normal version of phrase 3*B*. He states that two other male birds which he caught as first-autumn juveniles also produced abnormal songs of this type. From observations of these four birds, he concluded that the chaffinch song has an inborn basis, but that the third part of the song and the pitch and rhythm of the first two parts have to be learnt. He also considered that the learning is due solely to imitation during a relatively short period of a few weeks in the early spring of their first year of adult life. It now seems clear that these conclusions need a good deal of modification.

The first step was, of course, to prove that rearing in aviaries and cages did not necessarily affect the song pattern. Thirty control birds have now been recorded in these circumstances, and so we have a fairly precise picture of the 'normal song' (Fig. 1). The first series of experiments then consisted in taking birds which had been reared normally by their own parents, and isolating them from their first September onwards in order to study the development of their songs in the ensuing spring. It was soon found that it is not necessary for such birds to see other singing chaffinches in order to acquire normal songs. Even if such birds are caged with song birds of other species and so subject to an overwhelming 'barrage' of alien song, they can still attend only to the normal song of their species which they hear from the outside; and our experimental birds failed to show any sign of acquiring the alien songs to which they were exposed, though it is said that the chaffinch will sometimes incorporate the notes of other species in its sub-song[5]. In this lack of general imitation the chaffinch is in marked contrast with the bullfinch (*Pyrrhula pyrrhula*) and the greenfinch (*Chloris chloris*), which will learn complete songs from an alien species. In these experiments, seven chaffinches were exposed to canary song in the bird room, three to greenfinch song and two to goldfinch song in aviaries, without any abnormality resulting.

If such birds isolated as juveniles are kept out of hearing of *all* bird song from September until the

following May, but are allowed to hear vocalizations of other chaffinches treated in the same way, a clear difference is noticeable. Phrases 1 and 2 of the songs are practically normal, although they show much variation; but there is a slight tendency for the endings to be abnormal and to approximate to a community pattern. Twenty-seven birds were treated in this way and were isolated in six distinct groups. Fig. 2 shows the sound spectrograms of two genetically unrelated birds which have developed songs closely similar in ending as a result of being thus confined together. They are fairly representative of the general run of the experiments.

If we now repeat such an experiment using instead birds which have been hand-reared and have thus been isolated from contact with experienced birds since the first few days of nestling life, we get a very different result. Phrases 1 and 2 are now often inseparable, and phrase 3*A* is always lacking. Phrase 3*B* is often lacking also, or at most is represented by a single 'squeak' of fairly steady pitch though often of considerable frequency-range. Each isolated community of such birds builds up during the period February to April inclusive an entirely individual but extremely uniform community pattern, the resemblances throughout the song being so close that it is often very difficult to distinguish the songs of the different members of the group one from another even when subjected to a detailed analysis by the sound spectrograph. Figs. 3, 4 and 5 show the sound spectrograms of such groups of birds. The first pair (Fig. 3) were kept together in isolation during 1951–52 and had no contact with any other birds at all. The second pair (Figs. 4*a* and *b*) were similarly isolated 1952–53, while Fig. 5 shows the pattern produced by members of a group of five kept together in isolation during 1952–53. Inspection of the figures will show that the detailed resemblances are extraordinarily exact and concern all parts of the song, and the second of these song-types is quite unlike anything that has yet been recorded from the wild.

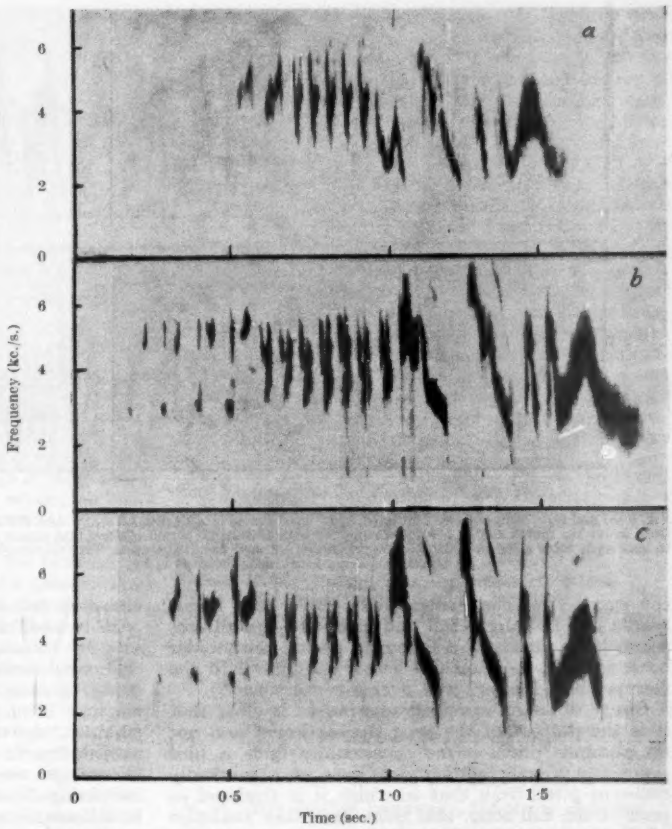

Fig. 2 (*a*) and (*b*). Songs of two 1951 chaffinches (*BY/RWB* and *O/GY*) reared by their own parents but isolated as juveniles of five months and allowed only to hear the members of their own group of five birds identically treated during their critical song-learning period in 1952. Note very close resemblance of latter parts of song. (*c*) Song of *O/GY* in 1953, to show fixity of song in second year even though given opportunity to hear many varieties of chaffinch song in second season. These three songs can be regarded as 'normal'. Scales as in Fig. 1

It appears, then, that the difference between the hand-reared birds and those which had a normal fledgling and early juvenile life, but which were isolated from September onwards, is only explicable on the assumption that some characteristics of the normal song have been learnt in the earliest youth before the bird itself is able to produce any kind of full song. It seems that these birds have by their first September learnt that the song should be in three phrases, and that the terminal phrase should contain a more-or-less elaborate flourish. The details of this terminal phrase with its flourish are apparently not learnt then but are worked out by competitive singing with other members of the group in the following spring.

The experiments with the hand-reared birds suggest that there is an inborn basis to the song but that it is extremely generalized. Innately these birds seem able to produce a song of about the normal length, 2·3 sec., and showing a tendency to *crescendo* accompanied by a fairly steady fall in mean frequency. There is no clear indication of any inborn division of the first part of the song into phrases 1 and 2, but there is a clear tendency in some birds to conclude the song with a single simple note of a higher pitch than the rest. They seem quite unable, by themselves, to produce anything more complex in the way of an ending although, as Fig. 5 shows, they can learn, by a process of mutual stimulation and imitation, to produce precisely controlled and highly elaborate song patterns in what corresponds to phrase 2 of the normal song. (While the present evidence points to the conclusion that these features of the songs produced by hand-reared birds are inborn, we must remember that it has not yet been possible to rear such birds in isolation in the soundproof room right from the egg. Until this has been done, which we hope will be in the near future, the possibility cannot be ruled out that some details of the song are learnt by the nestling in the first few days after hatching, or even during the last hours in

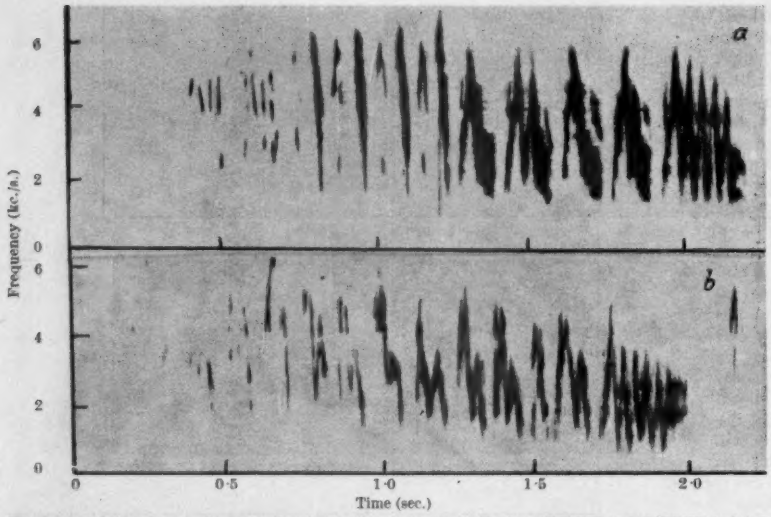

Fig. 3 (*a*) and (*b*). Songs of two unrelated 1951 hand-reared chaffinches (*BY/PW* and *RWB/Y*) isolated from about the fourth day of life and during the critical learning period of their first season allowed only to hear each other's songs. (Recorded April 1952.) Note: Songs abnormal, relatively simple and closely similar. Phrase 3 lacking. Scales as in Fig. 1

the egg. That chaffinches which have been hand-reared can be taught full and elaborate end-phrases when kept during the following spring with older birds selected for their fine songs was known to the German bird fanciers well over a century ago[6].)

Study of sound spectrograms makes it clear that it is the pattern of the song that is learnt and not its absolute pitch. One occasionally finds a bird practising a song ending *sotto voce* at a markedly different pitch from that in which it is rendered as part of the full song, and there are other examples of slight change in pitch with changes in intensity of motivation.

Once a song has been acquired and has been sung for a period of a few days at full intensity, it becomes fixed and subsequent changes are extremely slight. The individual songs of fifteen different birds have now been recorded and analysed in two or more subsequent years, and in nearly every case the differences between the first and second year are so minute as to be practically imperceptible to the naked ear although they will show up on the spectrograph records. Figs. 2*b* and *c* show the songs of the same bird in 1952 and 1953. As Fig. 2*c* shows, a bird in its second year may retain characteristic features in its song which involve a frequency change of a few hundred cycles or less and of only 10–20 m.sec. duration. Such slight changes that do occur involve small differences of emphasis and occasionally the alteration of a phrase or perhaps the omission of the repeat of a phrase which was doubled in the former year. The sound spectrograph has, however, unexpectedly provided evidence that there is a slight but almost uniform tendency for the song to be shorter, by about 0·1–0·3 sec., in the second year than in the first, and that there is also a slight tendency to increase the frequency-range in all phrases of the song. There is as yet no clue why this should be so.

It is possible to delay the period of learning a song by keeping the birds together in aviaries under such conditions that they will not sing for the time being, although they see and hear normal birds singing. If such birds are transferred in the summer (that is, July) to a chamber where they are artificially subject first to a gradually decreasing day-length for about eight weeks and then, in early October, to an increasing day-length, their gonad growth will again be stimulated and they will be brought into full song in the autumn (October–November). During this period they show evidence of acquiring the song ending by learning in the same way that they would have done had they been allowed to sing in the spring. Birds can also be brought into song at any

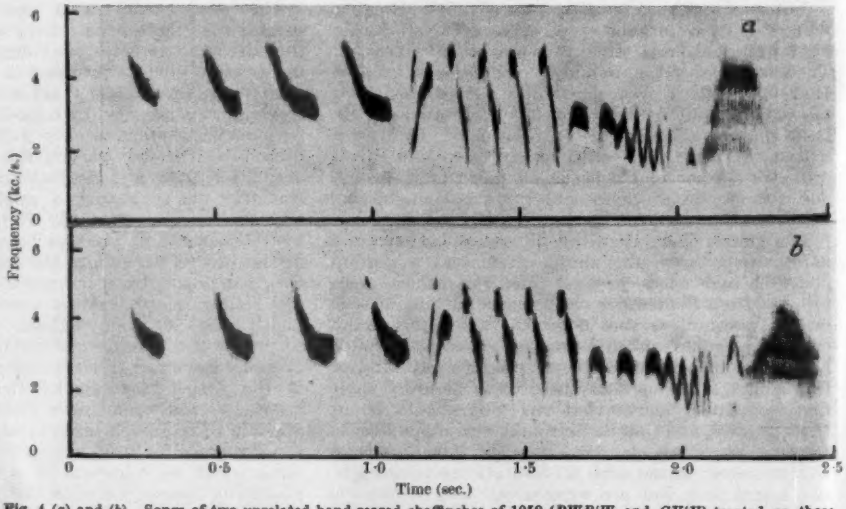

Fig. 4 (*a*) and (*b*). Songs of two unrelated hand-reared chaffinches of 1952 (*RWB/W* and *GY/Y*) treated as those shown in Fig. 3. (Recorded June 1953.) Note: Phrases 1 and 2 elaborate but highly abnormal. Phrase 3 extremely simple. The two songs are identical in almost every respect. Scales as in Fig. 1

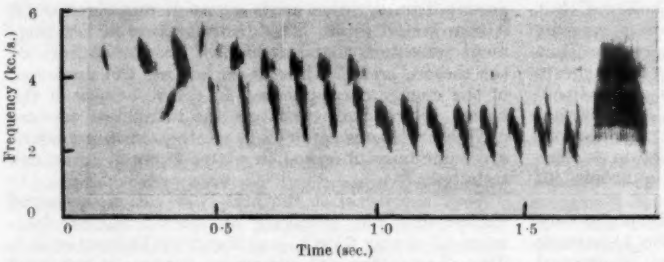

Fig. 5. Song typical of those produced by all members of a group of five 1952 hand-reared chaffinches treated exactly as those shown in Figs. 3 and 4. (*GW*⁵, recorded June 1953.) Note: Abnormal song with extremely simple phrase 3*b* (3*a* lacking). Scales as in Fig. 1.

season of the year by injection with the hormone testosterone propionate. Songs induced by the light method or by hormone injection seem not to differ in any way from the normal.

Bird fanciers rearing these and other finches have long been familiar with the 'sub-song' which precedes the true song in the late winter or early spring. In the chaffinch, this sub-song consists of a long continued and rather irregular warbling which, as the day-length increases and the production of sex hormone (as indicated by the change in colour of the bill) rises, slowly gives place to the phrases of the true song. The process gives to the listener the impression of the true song, so to speak, 'crystallizing out' of the amorphous sub-song. While the sub-song is undoubtedly to some extent a product of the lower degrees of motivation, in that it occurs in the second and later years as well as the first, yet it is much more in evidence in the first and seems to play some part in the process of learning the full song. When studied by the sound spectrograph, the sub-song appears to have a much greater frequency-range than the true song, and one at least of the processes by which the sub-song is transformed into the true song consists of the gradual dropping out of the extreme frequencies which have no place in the latter. The whole matter of sub-song and its differing types and functions in different species is one which requires much more investigation and cannot be dealt with here. Such sub-songs are seldom noticed in the wild because of their low intensity, and also because the bird often sings in very close cover instead of from a conspicuous song post as when producing the true song. Nevertheless, though inconspicuous, the sub-song is, in the chaffinch, a significant feature in the process of song acquisition.

To summarize: We can at present conclude that the normal chaffinch song of three phrases has a very restricted inborn basis amounting to little more than the ability to produce a song of about the normal length (2·3 sec.) and consisting of a *crescendo* series concluded by a single note of relatively high 'pitch'. All further refinements have to be learnt; but the innate basis of the song is probably sufficiently selective to ensure that the bird does not normally acquire notes or songs from any species other than its own. Some learning of details of the first part of the song and also learning of the fact that the song 'should' end in a relatively complex terminal flourish (phrases 3*A* and *B*) can take place in the first weeks of life—before, of course, the bird itself is capable of singing. But during this time no details of phrase 3 are acquired. This last phrase, together with more refinement in the early part of the song, is acquired during a period of high learning ability lasting for a period of a few weeks in the bird's first spring, when it is attempting for the first time to sing in competition with other chaffinches. This results in the development, in isolated groups of hand-reared birds, of distinct community patterns of song; and there is little doubt that the same process of 'imitation' results in the establishment in the wild of the local song 'traditions' which have so long been recognized in this species. There is some evidence that the 'sensitive period' can be delayed for some weeks by experimental treatment, and it sometimes happens that a bird can at a later stage acquire a second song in addition to its first. The song, once acquired, is retained with little or no alteration in subsequent years. The learning is of a pattern independent of pitch, though the birds are able to maintain a constant pitch with great accuracy. Some references on the sound spectrograph are appended[7–9].

[1] Ward, Thomas, "The Bird Fancier's Delight" (1714).
[2] Thorpe, W. H., *Ibis*, **93**, 1 and 252 (1951).
[3] Marler, P., *Ibis*, **94**, 458 (1952).
[4] See Poulsen, H., *Behaviour*, **3**, 216 (1951).
[5] Falconer, D. S., *Brit. Birds*, **35**, 98 (1941).
[6] Bechstein, J. M., "Naturgeschichte der Stubenvögel" (1795).
[7] Potter, R. K., *Science*, **102**, 463 (1945).
[8] Koenig, W., Dunn, H. K., and Lacy, L. Y., *J. Acoust. Soc. Amer.*, **18**, 19 (1946).
[9] Joos, M., *Language*, **24**, No. 2, supp. (Language Monograph No. 23, "Acoustic Phonetics"; 1948).

EXCITED NUCLEONS

By Prof. C. F. POWELL, F.R.S.
H. H. Wills Physical Laboratory, University of Bristol

DURING the past year, evidence has gradually accumulated for the existence of a new type of nuclear excitation which appears to be due to the presence, within a nucleus, of a neutral hyperon*, now designated Λ^0. It is believed that this particle can be bound to the other nucleons of a nucleus to form a relatively stable structure as measured on a nuclear time-scale, and that the eventual disintegration of such a nucleus is due to the decay of the Λ^0-particle.

The existence of the Λ^0-particle, which until recently was referred to as the 'heavy neutral *V*-particle', was established by experiments on the cosmic radiation with Wilson chambers. It was shown to be the more common of the neutral particles which produce the 'neutral *V*-events' discovered by Rochester and Butler[1] in 1947. Most of these events are now known to be due to two types of particles: (i) Λ^0, which decays into a proton and a negative π-meson: $\Lambda^0 \rightarrow P + \pi^-$, with a release of energy between 35 and 40 MeV.[2]; and (ii), θ^0, a heavy neutral meson which transforms into two light mesons, probably π-particles: $\theta^0 \rightarrow \pi^+ + \pi^-$, with an energy release of approximately 210 MeV.[3,4]. The mean life-times of the two types are approximately $t_{\Lambda^0} \sim 3 \times 10^{-10}$ s., and $t_{\theta^0} \sim 2 \times 10^{-10}$ s., respectively[5].

It is now known that the Λ^0-particle can be produced in nuclear interactions in which the available kinetic energy is insufficient to provide all the rest-

* The nomenclature employed is that recently proposed by Amaldi *et al.* (*Nature*, **173**, 123; 1954). A hyperon is a particle with mass between that of the neutron and that of the deuteron.

mass of the particle[6,7]. It is therefore believed that it results from a modification of a nucleon as a result of the collision. This fact, and the observation that in its decay it is transformed into a proton, suggests that it may be useful to regard it as an 'excited' nucleon. An excited atom can return to its normal state of energy by emitting a quantum of radiation, a photon; by analogy, an excited nucleon is conceived to relax by emitting a 'heavy quantum' of the nuclear field, that is, a π-meson.

It has recently been found possible to make very accurate measurements of the mass of the Λ^0-particle by the photographic method. In a stack of stripped emulsions, exposed at high altitude, Friedlander, Keefe, Menon and Merlin[8] in Bristol have found eight examples of tracks due to the decay of Λ^0-particles in each of which both the secondary proton and the negative π-meson are arrested in the stack. The ranges of the two particles can thus be measured, and thence their energies. These observations, and the angle of inclination with which the two particles are ejected, permit an accurate evaluation of the energy release, Q. The mean result thus obtained is $37{\cdot}2 \pm 0{\cdot}5$ MeV. in satisfactory agreement with the cloud-chamber observations. The corresponding value of the mass of the Λ^0-particle is $2{,}182 \pm 2\ m_e^*$. The quoted errors in the energy release are those deduced from the inner consistency of the measurements. The final value may have to be amended when a more accurate range–energy relation for protons has been established.

The original discovery suggesting that hyperons can exist not only as free particles but also bound within nuclei was due to Danysz and Pniewski[9]. They observed a heavy nuclear fragment, of charge $\sim 5\ e$, emitted from a nuclear disintegration recorded in a photographic plate exposed to the cosmic radiation. The particle appeared to reach the end of its range, where it disintegrated with the emission of three or four charged particles.

The striking feature of the observation was that the disintegration occurred at the end of the range, when the parent particle was at rest, or moving with very low velocity. The secondary disintegration could not therefore be due to a collision of the fragment with another nucleus. Instead, it was attributed to the spontaneous disintegration of the fragment. This view, however, had to meet the following difficulty. When a nucleus is struck by a nuclear particle, such as a proton, large amounts of energy can be conveyed to it so that it becomes violently excited. We picture the nucleons as being put into a state of violent motion, a motion of 'thermal agitation', as a result of which the nucleus disintegrates, several of its nucleons being 'evaporated'. The time for such a process is believed to be of the order of 10^{-20} s. In the case of the fragment observed by Danysz and Pniewski, however, its time of flight, from the instant of its ejection to the moment of arrest at the end of its trajectory, was $\sim 3 \times 10^{-10}$ s. The particle, therefore, survived at least several million times longer, before disintegrating, than would be expected according to our conventional picture of nuclear excitation.

In order to resolve this difficulty, Danysz and Pniewski suggested that the observed effects were due to the presence, among the nucleons of the fragment, of a hyperon—an excited nucleon. The observed disintegration was then associated with the decay of the hyperon. Alternatively, they suggested that the fragment might have emerged from the parent disintegration with a meson moving around it in a bound orbit. The disintegration of the fragment was then to be attributed to the capture of the meson, and the liberation, among the nucleons, of the energy corresponding to the rest-mass of the meson. Such disintegrations due to nuclear capture of free π^--mesons arrested in photographic emulsions are commonly observed in plates exposed to cosmic radiation.

Very shortly after the first observation, a second similar example, involving an ejected nuclear fragment of charge 2 or 3, was found by Tidman *et al.*[10]. This observation was important because it appeared to eliminate the possibility, certainly very remote, that the original event was due to the chance occurrence, precisely at the end of the track of the nuclear fragment, of a small unrelated disintegration.

Some months later, two further similar events were discovered by Crussard and Morellet[11] and by Freier[12], which appeared to exclude the possibility that the phenomenon was to be attributed to a π-meson in a bound orbit. In each of the new events, a small disintegration with three secondary charged particles occurred at the end of the range of an ejected nuclear fragment of small charge, and one of the secondary particles could be proved to be a π-meson. Such an observation cannot be interpreted in terms of the nuclear capture of a π-meson, as this would provide insufficient energy to account for the disintegration. This difficulty could be avoided if the captured meson were assumed to be of greater mass—a $\varkappa$-meson, for example. In both the new events, however, the release of kinetic energy appeared to be of the order of 40 MeV., a value consistent with the original assumption of the presence of a Λ^0-particle among the nucleons of the ejected fragment. Very strong evidence for the correctness of this view has now been provided by two further examples which, because of the simplicity of the nuclear systems involved, allow a very precise analysis.

In the example described by Hill *et al.*[13], the ejected particle is probably a nucleus of mass number 4, charge 2. At the end of its range it appears to disintegrate into a π-meson and two other charged particles. If the transformation is represented:

$$^4\mathrm{He}_2^{\uparrow} \rightarrow {}^3\mathrm{H}_1 + {}^3\mathrm{He}_2 + \pi_{-1},$$

there is a momentum balance among the secondary charged particles, and the release of energy is $\sim 33{\cdot}8$ MeV. A detailed analysis, using the accurate value for m_{Λ^0}, shows that, if the above interpretation is correct, and if the original fragment contains a Λ^0-particle within it, the binding energy of the latter is ~ 4 MeV. This value may be compared with the energy required to remove a neutron from an α-particle, namely, ~ 20 MeV.

An event recently described by Bonetti *et al.*[14] allows an even more detailed analysis. The mass of the ejected fragment, of charge e, can be determined, and the value found is $\sim 5{,}500\ m_e$—approximately the mass of the triton. At the end of its range, the particle disintegrates into two charged particles which recoil in opposite directions, so that the two tracks are collinear. One of the secondary particles is a π^--meson of great range which, on stopping in the stack, is captured by a nucleus and disintegrates it. The other produces a short recoil track. If this particle is assumed to be a nucleus of helium-3, as appears to be demanded by the need to conserve

mass-number and charge, its momentum, as deduced from its range, is found to equal that of the π-meson. The transformation may therefore be written :

$$^3H^\dagger \rightarrow {}^3 \quad e_3 + \pi_{-1}.$$

The total release of energy is 41·5 MeV., a value which corresponds to a binding energy of the Λ^0-particle to the other two nucleons of the excited triton equal to about 1·5 MeV.

The latest two events, which allow such a close analysis, appear finally to exclude the possibility that the phenomenon under discussion is to be explained in terms of a meson in an orbit around the nucleus. Such an explanation, in the case of a light meson (π), has already been eliminated by the observed emission of π^--mesons from the disintegrating fragment ; but the possibility of a heavy meson remained. In the last two events, however, there is a momentum balance among the charged secondary particles, and the total release of kinetic energy is about 40 MeV. If the disintegrations are attributed to the nuclear capture of a negative heavy meson, an energy of $\sim$ 300 MeV. remains unaccounted for. The emission of a neutral particle, or particles, of high energy and momentum, would therefore have to be assumed. The observed momentum balance, so convincingly demonstrated in the event described by Bonetti *et al.*—together with the values of the binding energy of the Λ^0-particle deduced on the basis of the alternative assumption—would then have to be regarded as fortuitous. Such a possibility is remote and can be rejected on the grounds of its extreme improbability. It appears, therefore, that the explanation in terms of a Λ^0-particle is alone acceptable.

In view of the many laboratories now working on the subject, it seems certain that many further examples permitting a detailed analysis will soon be found. In time, it should be possible to determine the binding energies of the Λ^0-particle in a variety of nuclear species. It has been pointed out by Cheston and Primakoff[15] that a particularly interesting example, not hitherto observed, would be an excited deuteron :

$$^2H_1^\dagger \rightarrow {}^1H_1 + {}^1H_1 + \pi_{-1}.$$

It remains to be seen, however, whether the cohesion between a Λ^0-particle and a single proton is strong enough to render such an assembly sufficiently stable to be observed.

It has been suggested in an earlier paragraph that it may be useful to describe the Λ^0-particle as an excited nucleon, but it is already clear that the analogy is of limited validity. An excited hydrogen atom, to use the simplest example, consists of a proton and an electron in a state of higher energy than in the normal atom. The analogy might then suggest that the excited nucleon consists of a proton and an associated π^--meson—that the Λ^0 is a composite particle. Such a view could not have been finally excluded while our knowledge was confined to the decay of the free Λ^0-particles. Their relative stability as components of nuclei appears, however, to do so, for it is generally believed that, when captured by a nucleus, a π^--meson interacts with its nucleons in a time short compared with 10^{-12} s., the disappearance of its rest-mass providing the energy of the disintegration. In the event described by Bonetti *et al.*, however, the nuclear fragment persisted for longer than 2×10^{-10} s. before disintegrating. If the Λ^0-particle consisted of a π^--meson bound to a proton, it is difficult to see how the nuclear fragment could persist for such a long time on a nuclear time-scale. One would expect the bound π^--meson to disintegrate the nucleus just as it does when captured from outside.

These considerations suggest that the Λ^0-particle is an excited nucleon in a different sense from that suggested by familiar analogies. We are entering a new field where basically new concepts remain to be established ; but it seems reasonable to conjecture that the nucleon is transformed into an excited nucleon as a result of changes in its internal constitution. If so, we are beginning to make a new penetration into what Maxwell called "the strange strata of the material world", a penetration into the world of the nucleon. It seems that matter is inexhaustible.

[1] Rochester and Butler, *Nature*, **160**, 855 (1947).
[2] See discussion, Bagnères Conf. Report (1953).
[3] Barker, *Proc. Roy. Soc.*, A, **221**, 328 (1954).
[4] Thompson, Buskirk, Cohn, Karzmark and Rediker, Bagnères Conf. Report, p. 30 (1953).
[5] See discussion, Bagnères Conf. Report (1953).
[6] Fretter, Gregory, Johnston, Lagarrigue, Meyer, Muller and Peyrou, Bagnères Conf. Report, p. 26 (1953).
[7] Fowler, Shutt, Thorndike and Whitmore, *Phys. Rev.* (in the press).
[8] Friedlander, Keefe, Menon and Merlin, *Phil. Mag.* (in the press).
[9] Danysz and Pniewski, *Phil. Mag.*, **44**, 348 (1953).
[10] Tidman, Davis, Herz and Tennant, *Phil. Mag.*, **44**, 350 (1953).
[11] Crussard and Morellet, *C.R. Acad. Sci., Paris*, **236**, 64 (1953).
[12] Freier, reported by Ney, Bagnères Conference, mimeographed report, p. 253 (1953).
[13] Hill, Salant, Widgoff, Osborne, Pevener, Ritson, Crussard and Walker, *Bull. Amer. Phys. Soc.*, **29**, 60 (1954).
[14] Bonetti, Levi, Setti, Panetti, Scarsi and Tomasini, *Nuovo Cimento*, **11**, 210 (1954); and private communication.
[15] Cheston and Primakoff, *Phys. Rev.*, **92**, 1537 (1953).

OBITUARIES

Mr. Albert Campbell

ALBERT CAMPBELL, who died in Cambridge on February 6 at the age of ninety-one, will long be remembered as a pioneer in electrical science, especially in the fields of alternating current measurements and standards. He was one of the small band of men who under Glazebrook's leadership built up the National Physical Laboratory from almost nothing in 1901 to the research laboratory with a world-wide reputation that it had already become when Glazebrook retired in 1919. Campbell himself retired a little before Glazebrook, though not for the same reason ; he had not reached the customary retiring age, but he realized that conditions were changing. To be a leading member of a research team in a government laboratory was a very different prospect from being a pioneer opening up new ground with freedom to move in whatever direction the spirit prompted. He retired and continued to work at home with home-made instruments, until, with a failing memory, he found himself no longer able to do scientific work.

The main body of Campbell's work was, of course, done at the National Physical Laboratory between 1901 and 1919, the most important single item being his primary standard of mutual inductance, constructed in 1907 and still the ultimate reference standard for nearly all the measurements of inductance, capacitance and related quantities made in

Great Britain. The work he did after his official retirement was, however, no less remarkable. It included his alternating-current potentiometer, which in some respects has not been surpassed, and also his best method for the absolute determination of the ohm. Has any other man three absolute methods to his credit? Naturally enough, with home-made instruments his accuracy was limited to barely 1 part in 10,000, but when elaborated at the National Physical Laboratory his method proved to rank with the best known to-day.

It is scarcely possible to indicate the scope of his work in a short note, but it is worth recalling that he devised the inductometer (his name for a continuously adjustable and direct-reading standard of inductance), the constant-inductance rheostat, the vibration galvanometer, the 'waveform sifter', one of the earliest electrical filters and the forerunner of the modern twin-T bridges. He set up the first standard wavemeter at the National Physical Laboratory, calibrated it absolutely by counting flashes in an oscillatory arc, and showed that the result agreed with values calculated from his measurements of inductance and capacitance. He also devised many alternating current bridges and methods for measuring all the magnetic properties of importance to the electrical industry.

Campbell's strong practical bent is the more remarkable in that at Cambridge he first read for the Mathematical Tripos, from which he went on to the natural sciences. In 1893 Alexander Russell persuaded him to go to Faraday House, London, where he remained until he joined Glazebrook. It was no doubt there that he acquired his insight into the scientific needs of the rapidly growing electrical industry, which he served so well in his own inimitable way later.

It is remarkable that, with one notable exception, none of the scientific honours that it is customary to shower on a man of his distinction seems to have come his way. He was a man of singular personal charm who showed the same interest in all his fellow-workers from the boy in the workshop to the clerk in the office and the most eminent scientific men of his time. One of these last once remarked of him that "Nobody had a kinder heart or a sharper tongue", from which it may be inferred that he was sometimes a thorn in the flesh of the authorities. In 1925 the Physical Society awarded him the Duddell Medal, and never was that honour more appropriately bestowed or more richly deserved.

L. Hartshorn

Prof. D. S. Belyankin

With the death of Dmitry Stepanovich Belyankin, the U.S.S.R. has lost one of their most prominent petrologists. He was born on August 23, 1876, in Lomanikha, Vologda district, and died on June 20, 1953, in Moscow. Trained as a chemist under G. Tammann in the University of Youriev (Dorpat), he occupied successfully the posts of lecturer and of professor of mineralogy and petrology in the St. Petersburg Polytechnic Institute.

After his election as corresponding member of the Academy of Sciences in 1933, he became a member of the Petrographical Institute of the Academy, and moved to Moscow in 1935. In 1943 he was elected a full member of the Academy and after that he occupied a number of its more important posts, being director of the Petrographical Institute and the Mineralogical Museum, editor of the Geological Section of the Bulletin and co-editor of the *Compte Rendu* (*Doklady*) of the Academy.

Belyankin published some three hundred and eighty papers and books (many of them written in collaboration), dealing with mineralogy, regional and descriptive petrology and technical petrology. He was particularly interested in feldspars, clay minerals and other silicates, and described and named several new species. He described various igneous rocks from Northern Russia, the Ural Mountains and the Caucasus, and wrote papers on magmatic differentiation and the nomenclature of igneous rocks. He was particularly interested in the development of technical petrology, of which he was the acknowledged master. He created the Russian school in this subject and he and his collaborators contributed a large number of works dealing with the study of refractories, ceramic products, glasses and metallurgical slags.

Belyankin combined an all-absorbing devotion to science with a friendly disposition towards all his pupils and friends, among whom I was proud to be included.

S. I. Tomkeieff

Prof. Giorgio Valle

Italian science has suffered a grievous loss by the sudden death last December of G. Valle, head of the Department of Physics and director of the Righi Institute of the University of Bologna. Valle, who was born on December 15, 1888, at Trieste, read physics at the University of Vienna, where, having taken the degree of Dr.Phil., he worked as a demonstrator under E. Lecher until 1914. After the First World War, Valle taught for a short time at the Technical School at Terni and was later appointed professor at the Technical Institute at Bologna. In 1922 he moved to Asti, where he taught science at the Classical High School, at the same time lecturing to advanced students at the University of Turin. In 1932 he was appointed professor of experimental physics at the University of Ferrara, and in 1933 to the chair of physics at Parma, which he held until 1947. In that year he was elected to the chair of physics at Bologna, a post formerly held by A. Righi and Q. Majorana.

Valle, an assiduous worker, published more than seventy papers, mostly in *Nuovo Cimento*, the proceedings of the Accademia dei Lincei and of the Accademia di Torino, the *Wiener Berichte* and the *Physikalische Zeitschrift*. He made a series of notable contributions in the field of electric discharges, also in magnetism, acoustics, physical optics and meteorology. He was author or co-author of several text-books as well as of a volume of extracts from Righi's papers (see *Nature*, **167**, 174; 1951) which he published in collaboration with G. C. Dalla Noce.

Valle was a man of great energy and vitality, and although during the past few years handicapped by the loss of his voice, he continued his scientific work until a month before his death. At the Righi Centenary Celebrations at Bologna in 1950, Valle, as an officer of the Italian Physical Society, was host to scientists from many countries, including Great Britain. A few months before his death he was at last able to gratify his wish to visit England, where he took part in the Oxford conference on ionization phenomena.

A. von Engel

NEWS and VIEWS

Scientific Adviser's Branch, Home Office : Sir Edward Paris, C.B.

SIR EDWARD PARIS, who has recently retired from the position of chief scientific adviser to the Home Office, received his early scientific training at the Imperial College of Science and Technology and at University College, London, where he worked with Prof. A. W. Porter on the polarization of light. During the First World War he saw service in a Sound-Ranging Section in France. He there came into contact with Major W. S. Tucker, and, after the War, Tucker and Paris collaborated first at the Munitions Inventions Department and afterwards at the Signals Experimental Establishment, Woolwich, in their investigation of the use of the hot-wire microphone for sound detection. Between the two Wars, Paris worked as an experimental officer in the Air Defence Experimental Establishment until, in 1938, he was appointed deputy director of scientific research at the War Office under Dr. H. J. Gough. A year later the scientific branches were transferred to the Ministry of Supply, and it was there, under the stress of war, that Paris showed great qualities as a scientific administrator. Like others in senior posts in that Ministry at the time, he went through a bewildering succession of changes of designation, denoted by ever more complicated initials; but he remained unperturbed and unperturbable, and the work went on. In 1946 he was principal director of scientific research (defence). He was created C.B. in 1947. In 1948 he was appointed to the Home Office, and there, as chief scientific adviser, he has been conspicuously successful in directing the research and advising on the scientific problems arising in the civil defence planning in Britain for which the Department is responsible. The conferment of a knighthood on him, announced in the New Year Honours, has given great pleasure to his friends and colleagues.

Dr. R. H. Purcell

DR. R. H. PURCELL, who has been appointed to the post of scientific adviser to the Home Office in succession to Sir Edward Paris, took a degree in chemistry at the Royal College of Science in 1924. After conducting research under Prof. H. B. Baker, he was elected to a Ramsay Memorial Fellowship which he held at Amsterdam and the Royal College of Science. He later became lecturer in physical chemistry in the Royal College of Science. He joined the scientific staff of the Admiralty during the War, and was occupied on a number of scientific inquiries which were of urgent practical importance. In 1947 Dr. Purcell was promoted to the rank of senior principal scientific officer for special scientific merit, and has only recently been made a deputy chief scientific officer in the Royal Naval Scientific Service. Since the War Dr. Purcell has been directly concerned with the naval aspects of defence against atomic weapons, and these experiences will be important to him in his new duties.

Canning Section of the Low Temperature Research Station, Cambridge : Mr. T. N. Morris

MR. THOMAS NORMAN MORRIS, who retired at the beginning of this year from his post as head of the Canning Section of the Low Temperature Research Station, Cambridge, was born in 1889 at Haddenham, Isle of Ely (Cambs), of local farming stock on both sides, and was educated in Cambridge at the County School for Boys and then at the University, being a scholar of St. John's College. After Part 1 of the Natural Sciences Tripos, in which his subjects were botany, chemistry, zoology and physiology, he read for the Agricultural Diploma and then in 1911 took botany in Part 2 of the Tripos. During the First World War he was bacteriologist for acetone production in H.M. Factory at King's Lynn and was later employed by the Ministry of Munitions on the production of picric acid as chemist in charge of the laboratory at Halifax, Yorks. After the War he was research chemist with the firm of Chivers and Sons, Ltd., Histon, Cambs, until in 1927 Sir William Hardy appointed him to be head of the Canning Section of the Low Temperature Research Station. Work in this Section was initially concerned with corrosion problems relating to tin-plate cans, but was later extended to include the freezing of fruits and vegetables, the concentration of fruit juices, the dehydration of foods and the behaviour of pectin in fruits during storage and processing, particularly in relation to the manufacture of jams and jellies. Apart from his scientific occupations, Mr. Morris's main interest is practical farming, and now that he has retired he intends to apply his scientific and agricultural knowledge to this end.

Prof. Otto Hahn

To mark the anniversary of his seventy-fifth birthday on March 8, Prof. Otto Hahn, the nuclear physicist, was awarded the Grand Cross, Second Class, of the Order of Merit of the Western German Federal Republic. He was invested with the insignia of the Order at the offices of the Max Planck Society, of which he is president; and on the same occasion he was awarded the Harnack Medal of the Society.

Napier Shaw Memorial Prize of the Royal Meteorological Society

MARCH 4 marked the centenary of the birth of Sir Napier Shaw, whose life extended into its tenth decade, spanning an era of scientific as of political revolution. Sir Napier's remarkable career can be divided into three main phases. As Fellow and senior tutor of Emanuel College, Cambridge, he established a reputation as a successful university teacher of physics, an occupation which he abandoned only at the turn of the century to become director of the Meteorological Office, and president of the International Meteorological Organization, in which capacities he probably did more than any other man of his time to promote the subject by encouraging new observational methods, a scientific treatment of data, and meteorological research generally. Finally, at the age of sixty-six, he became the first professor of meteorology at the Imperial College of Science and Technology, London, and there laid the foundation of formal training in the subject.

As a result of an appeal to the members of the Royal Meteorological Society and to scientific instrument manufacturers, a memorial fund has been raised by the Society to commemorate the unique position which Shaw achieved in British meteorology. It has been decided to use this fund for the regular award by competition of a Napier Shaw Memorial Prize. The competition will be open to anyone without restriction of nationality. The prize of £100 is offered on this occasion for an original essay on "The Energetics of the General Circulation". The

essay will be expected to treat of the energy transformations of the circulation as a general theme or any particular aspects of that theme. It may be an essay in which the author describes and discusses the salient and essential features of the general circulation and the energy transformations involved; it may be an essay which attempts an adequate synopsis and discussion of the observations, or a study of the thermodynamics and hydrodynamics of the circulation; or the essay may treat of any combination of these within the general theme. The essay, which must be in English, may include material which the candidate has already published. Essays may be submitted jointly in the names of more than one author. All entries must be addressed to the Assistant Secretary, Royal Meteorological Society, 49 Cromwell Road, London, S.W.7, and marked clearly 'Napier Shaw Prize', and should be received at the Society's Offices not later than March 4, 1956.

Royal Society of Edinburgh : New Fellows

The following have been elected Fellows of the Royal Society of Edinburgh: Dr. H. M. Adam, senior lecturer in pharmacology, University of Edinburgh; Mr. J. K. Allan, chief geologist, National Coal Board, London; Mr. B. L. Burtt, principal scientific officer, Royal Botanic Garden, Edinburgh; Dr. Enid Charles, reader in demography and vital statistics, University of Birmingham; Dr. E. F. Collingwood, Lilburn Tower, Northumberland; Dr. I. MacP. Dawson, senior lecturer in electron microscopy, University of Glasgow; Dr. J. Duckworth, Rowett Research Institute, Bucksburn; Mr. W. G. Emmett, reader in experimental education, University of Edinburgh; Dr. C. E. Foister, chief plant pathologist, Department of Agriculture for Scotland; Mr. H. D. Griffith, lecturer in natural philosophy (medical physics), University of Aberdeen; Prof. G. Hibberd, Dixon professor of mining, University of Glasgow; Prof. N. Kemmer, Tait professor of natural philosophy, University of Edinburgh; Mr. T. Lawrie, general manager, North of Scotland Hydro-Electric Board; Prof. R. D. Lockhart, professor of anatomy, University of Aberdeen; Dr. C. Long, senior lecturer, Department of Biological Chemistry, University of Aberdeen; Dr. D. K. C. MacDonald, director, Cryogenic Laboratory, Division of Physics, National Research Council, Canada; Miss Agnes E. Miller, lecturer in zoology, University of Glasgow; Prof. D. C. Pack, professor of mathematics, Royal Technical College, Glasgow; Dr. Mary Pickford, reader in physiology, University of Edinburgh; Dr. B. Raistrick, research manager, Scottish Agricultural Industries, Ltd.; Prof. G. S. Rushbrooke, professor of theoretical physics, King's College (University of Durham), Newcastle upon Tyne; Mr. G. I. Scott, consultant ophthalmologist, Edinburgh; Dr. N. B. Slater, lecturer in applied mathematics, University of Leeds; Dr. R. B. Strathdee, reader in chemistry, University of Aberdeen; Mr. J. Wallace, head of the Science Department, Melville College, Edinburgh.

Research into Rain-making

Replying in an adjournment debate in the House of Commons on February 23 to Mr. G. de Freitas's request for increased research into weather modification, the Under-Secretary of State for Air said that the Meteorological Office is studying reports of rain-making activities all over the world; but he was advised that available scientific evidence on the practical side is not entirely convincing. Since the Advisory Council on Scientific Policy expressed the opinion in 1951 that no expenditure of effort on large-scale field trials was called for without further research, the Meteorological Office has carried out research on cloud rainfall problems, and practical experiments have been made by the Meteorological Research Flight of the Royal Air Force, more with the object of increasing knowledge than of trying to produce rain. Rain-making, and the present state of our knowledge of the subject, will shortly come before the Physical Sub-Committee of the Meteorological Research Committee, which advises the Secretary of State for Air on this subject, and the future course of action will then be reconsidered.

National Institute of Sciences of India : Council and New Fellows

The Council of the National Institute of Sciences of India has been elected for 1954 as follows: *President*, Sir K. S. Krishnan; *Vice-Presidents*, Prof. S. K. Banerji and Dr. B. Mukerji; *Treasurer*, Prof. D. S. Kothari; *Foreign Secretary*, Prof. P. C. Mahalanobis; *Secretaries*, Prof. R. C. Majumdar and Dr. B. P. Pal; *Editor of Publications*, Prof. J. M. Sen; *Members of Council*, Prof. S. P. Agharkar, Prof. K. N. Bagchi, Dr. J. L. Bhaduri, Dr. Verrier Elwin, Prof. P. S. Gill, Prof. A. C. Joshi, Dr. V. R. Khanolkar, Dr. M. S. Krishnan, Dr. D. R. Malhotra, Prof. S. K. Mitra, Dr. M. A. Moghe, Dr. H. S. Pruthi, Prof. B. Sanjiva Rao, Dr. V. Subrahmanyan, Prof. N. R. Tawde, Mr. M. S. Thacker and Dr. A. C. Ukil; *Representative of the Government of India*, Dr. D. N. Wadia; *Representatives of the Asiatic Society*, Prof. H. K. Mookerjee and Dr. U. P. Basu; *Representatives of the National Academy of Sciences*, Prof. Shri Ranjan and Dr. R. K. Saksena; *Representatives of the Indian Science Congress Association*, Dr. S. L. Hora and Dr. B. N. Prasad; *Ex-Officio Members (Past Presidents)*, Dr. Baini Prashad, Dr. J. C. Ghosh, Dr. D. N. Wadia, Sir S. S. Bhatnagar, Prof. S. N. Bose and Dr. S. L. Hora.

The following elections have also been made to fellowships of the Institute. *Honorary Fellows:* Prof. Sydney Chapman, recently Sedleian professor of natural philosophy, University of Oxford; Prof. V. A. Engelhardt, Soviet Academy of Sciences, Moscow; Prof. W. Heisenberg, director of the Max Planck Institute, Göttingen; and Prof. Paul Karrer, director of the Chemistry Institute, University of Zurich. *Ordinary Fellows:* Dr. B. C. Basu, research officer in entomology, Indian Veterinary Research Institute, Izatnagar; Dr. S. K. Bhattacharya, assistant professor of chemistry, Institute of Technology, Kharagpur; Prof. K. Chandrasekharan, professor of mathematics, Tata Institute of Fundamental Research, Bombay; Prof. K. R. Dixit, professor of physics, Institute of Science, Bombay; Dr. S. Ghosh, professor of chemistry, University of Allahabad; Dr. A. G. Jhingran, superintending geologist, Geological Survey of India, Calcutta; Prof. S. Kilpady professor of geology, University of Nagpur; Dr. Z. R. Kothavala, director, Dairy Research, Government of India, Bangalore; Dr. L. S. S. Kumar, principal, College of Agriculture, Poona; Dr. N. V. Modak, special engineer, Bombay Municipality; Prof. C. Radhakrishna Rao, professor, Indian Statistical Institute, Calcutta; Mr. A. K. Roy, officiating deputy director-general of observatories, Meteorological Office, New Delhi; Dr. R. N. Sen, lecturer in mathematics, University of Calcutta;

Mr. M. R. Sen Gupta, principal of the Engineering College, Banaras Hindu University; and Dr. S. M. Sircar, lecturer in botany, University of Calcutta.

Vitaminization of Margarine

ALTHOUGH skim milk has a high nutritional value, it is not a popular article of diet and, consequently, the separation of milk fat for use as cream or butter results in a considerable wastage of the valuable proteins, minerals and water-soluble vitamins. There can be little doubt that nutritional economy demands the use of milk as whole milk, not separated into different fractions. In communities where butter has become a regular item in the diet, it then becomes necessary to find a butter substitute, chiefly as a 'spreader' for bread. Almost any hardened edible oil would do for this purpose; but in order to safeguard the health of those who will not take enough milk to yield the amount of milk fat they would otherwise have taken as butter, it is important that butter substitutes should be reinforced with the fat-soluble vitamins A and D to approximately the same levels as are normally found in butter. A high proportion of margarine of domestic quality in Britain was already being reinforced in this way in 1939; but it was only during the War that it became a statutory condition of licence to manufacture that these two vitamins should be added in prescribed quantities. Now that margarine is due shortly to be decontrolled, the Food Standards Committee of the Ministry of Food has recommended that all home-produced and imported domestic margarine should be required to reach the following levels: vitamin A, 760–940 international units/oz.; and vitamin D, 80–100 international units/oz. The recommended level for vitamin D is approximately the same as that at present prevailing; that for vitamin A is somewhat higher, the present level being 450–550 international units/oz. The report has been issued by the Ministry of Food.

Limits for Zinc in Foods

ALTHOUGH zinc is a normal constituent of the human body and its presence in the enzyme carbonic anhydrase suggests that it may be an essential element in the diet, nevertheless far more importance is attached to the necessity of avoiding an excessive intake than of ensuring an adequate one. The Food Standards Committee (Metallic Contamination Sub-Committee) of the Ministry of Food in a report, in a recent publication issued by the Ministry, recommends that the following limits should be observed: beverages which are ready to drink, 5 p.p.m.; and other foods, 50 p.p.m. But it adds that "in view of the high natural zinc content of certain animal and vegetable products, e.g. herrings, shell-fish, and crustacea, cereal offals and animal offals . . . no objection should be taken to the sale of such articles containing zinc in excess of 50 p.p.m. if it can be shown that the zinc is of natural occurrence". A maximum limit of 100 p.p.m. is already prescribed for edible gelatin and, apart from this, the Committee does not consider it necessary that statutory effect need be given to the limits recommended. It would appear that risk of zinc poisoning comes almost entirely from the use of zinc or galvanized iron equipment in kitchens and food stores. Such equipment is corroded not only by acid foods (for example, apples) but also by salt solutions, so that it is generally unsuitable for any cooking or food-storage purposes. The Committee also directs attention to the fact that "outbreaks of poisoning have been attributed to the inadvertent use of galvanised vessels, for example, to drinking rain water collected from galvanised iron roofs or stored in galvanised iron tanks". The main symptom of zinc poisoning is an outbreak of violent vomiting.

The Earth's Shadow

AN article in *l'Astronomie* (November 1953), entitled "Sur l'Ombre de la Terre", by J. Dubois, of the Bordeaux Observatory, gives the results of some recent research, and more especially of his own work carried out at the Pic-du-Midi Observatory and at Bordeaux, on the phenomenon of the earth's shadow or the anticrepuscular arch. This phenomenon, which occurs a short time before sunrise and a short time after sunset, is briefly described for sunset; but the same description in inverse chronological order applies also at sunrise. As soon as the apparent altitude of the sun is less than about 2°, a greyish-blue zone rises above the eastern horizon, slowly ascending as the sun sinks, changing in colour from blue to an increasing dark hue, and ending as a vast surbased arc, forming what is known as "the earth's shadow". Some minutes after sunset a whitish zone, somewhat bright, called "Albe" by M. Durand-Greville, is clearly distinguished, and to it is due the re-illumination of clouds or of the tops of mountains—phenomena which have puzzled many observers and for which various theories have been proposed. In a discussion of the history of the observations and aim of the researches, reference is made by M. Dubois to the observations of Gruner and R. P. Combier, the latter having published the results of his work during the years 1938–40. However, it is to M. Dubois that the most important work is due, and all who are interested in the phenomenon would be well advised to read the description of his equipment and his conclusions. In this short note, attention can merely be directed to a few of his deductions, from the time when he started work in 1945 until he completed it four years later. He points out that the conclusions deduced by observations with the spectrophotometer are consistent with his theories, and that the main factor in promoting the anticrepuscular arch is the ozone in the atmosphere localized between heights of 20 and 30 km. The blue tint observed must be attributed to the feeble intensity of the yellow and red radiations which are rather strongly absorbed by the ozone. It appears that absorption by aqueous vapour and oxygen has very little effect on the intensity and colour of the arch.

Blundell's School Science Society

THE recent edition of the *Magazine of the Blundell's School Science Society* (No. 8, 1952–53) reveals a year of considerable activity which continues to reflect exceptional credit on the School's activities, especially in biological field work. This practical work carried out by the boys is obviously well organized, for the papers published show the real research spirit. The School has now started a colony of bees, and a tank of sticklebacks is being kept not merely for amusement but also for behaviour studies. These practical activities are supplemented by periodic demonstrations and Sunday evening talks by visiting scientists. The opening meeting of the year was addressed by Mr. A. Stuart, head of the Geology Department, University College, Exeter. Then throughout the year, lectures on varying scientific topics were given.

The *Magazine* reports "Meteorological Records", by D. S. R. Wills, which is a summary of the local weather during October 1952–September 1953. In the bird-ringing work, 164 birds were ringed—125 from traps and 39 from nests. The Ornithological Section also gives a detailed analysis of nest record cards for 1953 (J. Beck), and an account of the birds of the Culmstock area. A paper entitled "A Study of the Influence of Light and Soil Properties on the Growth of Bracken" presents results of an excellent piece of field and experimental work by D. P. T. Burke. The realization that biology is the study of plants and animals living together in a community (rather than the uninspiring study of type specimens from books or, at most, dead bodies and pickle jars) comes out well in C. N. A. Clement's paper on "The Part Played by the Oak Tree in the Natural Plant and Animal Community of a Woodland". D. Knight Jones records some good experimental studies in his "Investigation of the Post-Floral Movements shown by the Garden Nasturtium". C. L. Honeybourne reports some "Observations on the Circulation of Nitrogen in the Grand Western Canal"; the field work here was carefully planned and carried out, and the observations include estimation of nitrogen in the water and of plankton. This excellent paper is accompanied by a table and two graphs. In the Spring Term of 1952, J. M. Saxon began some interesting observations on soil temperatures under natural conditions, using a thermistor.

Blundell's *Magazine* is a model of its kind and reflects great credit on the methods of science teaching in that School, for which Dr. M. Ashby, the biology master, is to be specially selected for congratulation.

Fungi Pathogenic to Man and Animals

A collection of fungi is maintained in the Laboratory of Mycology of the Institute Oswaldo Cruz (Caixa Postal 926, Rio de Janeiro, Brazil: List of Cultures, 1953). The workers in this laboratory are specially interested in the maintenance of cultures of fungi pathogenic to man and animals, though the list, which is a considerable one, contains many others, including plant pathogens. Scientists and institutions are asked to send cultures not included in the list. Cultures from the Institute's collection will be sent "to all institutions and scientists upon request and free of any charge".

A New Modelling Medium

A new modelling medium called 'Vinagel' is described in the November issue of the *Museums Journal* by Dr. H. F. Steedman, of the Zoology Department, University of Glasgow. At present it can be obtained in four grades, Nos. 116, 118, 500 and 577, from Vinyl Products, Ltd., Butter Hill, Carshalton, Surrey. To use the No. 116 grade it is sufficient to press it on a coin or other hard material, peel it away gently and bake in an oven for about twenty minutes at 170° C. On cooling, it will have the consistency of stiff rubber, will be highly resistant to deformation and virtually insoluble. With the softer varieties the material may be painted or dabbed with the 'Vinagel' until a sufficient thickness is obtained, and then the original and its covering must be baked as before. Its great optical resemblance when cured to bone suggests that one of its most important biological uses lies in osteology, though it will be certain to be of service to sculptors, artists and museum technicians.

Announcements

We regret to announce the following deaths:

Mr. S. F. Ashby, formerly director of the Imperial Mycological Institute, on March 6, aged seventy-nine.

Prof. E. P. Cathcart, C.B.E., F.R.S., emeritus professor of physiology in the University of Glasgow, on February 18.

Prof. J. L. Coolidge, emeritus professor of mathematics in Harvard University, aged eighty.

Prof. O. Diels, emeritus professor of chemistry in the University of Kiel, on March 7, aged seventy-eight.

Dr. N. G. Horner, formerly editor of the *British Medical Journal*, on March 7, aged seventy-two.

Owing to the increasing activities of the Society of Dyers and Colourists (19 Piccadilly, Bradford 1), the post of editor and general secretary of the Society, held by Dr. C. J. W. Hooper, has been divided, with Dr. Hooper continuing as editor and technical officer. The new post of secretary of the Society is being filled by Mr. J. W. Nicholls, who until recently has been working in Newcastle upon Tyne as secretary and organizer of the Federation of Master Builders.

Changes in the chairmanship in research boards of the Department of Scientific and Industrial Research have been announced as follows: *Building Research Board*, Sir Herbert Manzoni, city engineer of Birmingham, in succession to Mr. W. K. Wallace, chairman since 1949; *Food Investigation Board*, Dr. R. Holroyd, director of research, Imperial Chemical Industries, Ltd., in succession to Sir Frank Engledow, chairman since 1947; *Geological Survey Board*, Sir Walter Drummond, deputy chairman of the National Coal Board, in succession to Sir Arthur Trueman, chairman since 1943, who has retired from the post owing to ill-health; *Road Research Board*, Mr. E. J. Powell, county surveyor of Glamorgan, in succession to Sir Frank Smith, chairman since 1946.

The United Steel Companies, Ltd., have recently endowed a fellowship for research in ferrous metallurgy at the University of Sheffield, and Dr. A. R. Entwisle, who for some time past has been engaged in metallurgical research in Sheffield, has been appointed as the first holder. Dr. Entwisle will study the effect of interstitial elements on the formation of martensite.

As in former years, a course in tropical hygiene for laymen will be held by the Ross Institute of Tropical Hygiene, London, during July 26–30. The course is for workers in the tropics holding posts which entail looking after the health and welfare of others. Morning sessions will be devoted to malaria and its control, and in the afternoons other tropical diseases and problems, such as hookworm, bilharzia, nutrition, housing and sanitation, and protection against heat will be dealt with. There is no fee for the course. Further information can be obtained from the organizing secretary, L. G. Ponsford, Ross Institute of Tropical Hygiene, London School of Hygiene and Tropical Medicine, Keppel Street (Gower Street), London, W.C.1.

Erratum. In the communication entitled "Possible Existence of a Transition Point between β- and γ-Sulphur", by R. S. Bradley, Dr. N. H. Hartshorne and M. Thackray (*Nature*, February 27, p. 400), the legend on the ordinate of the graph should read "Log-rate (mm./hr.)".

ATOMIC WEAPONS*

IN ordinary explosives, energy is released at high speed as a result of the rearrangement of unstable molecules into more stable forms. Since the energy is of the same order of magnitude for all chemical reactions, chemical explosives much more powerful than those available at present will never be found. In atomic weapons, however, energy is generated by the rearrangement of particles in the atomic nuclei. Nuclei are always lighter than their constituent particles, and this mass defect is a measure of the energy that would be liberated if the nucleus could be built up from its components. Since the mass defect is greatest for elements of medium atomic weight, there are two possible sources of atomic energy, namely, the building up of nuclei of medium elements from lighter ones and the breaking down of heavy elements to medium ones. The latter is the fission process on which the atom bomb is based.

To produce an explosion, the release of energy must be practically instantaneous. The fission of uranium-235 or plutonium-239 can be made to fulfil this requirement if a chain reaction is set up propagated by fast neutrons. At each fission, two or three fast neutrons are liberated, and if the mass of the fissile material is great enough to ensure that more than one of these neutrons produces further fission, a chain reaction is initiated which runs its course in a few millionths of a second, producing a shock wave of unprecedented destructive force.

In January 1950, the President of the United States announced that he had directed the continuation of work on all forms of weapons "including the so-called hydrogen bomb". This made public the possibility of producing energy by the fusion of light elements into heavy ones. In January 1953 it was announced that a thermonuclear test had taken place at Eniwetok, and in August 1953 Malenkov stated that "the U.S. no longer has the monopoly of the hydrogen bomb".

Little is known publicly about the construction of the hydrogen bomb; but most probably it is based on the fusion of hydrogen nuclei into helium nuclei, taking place at very high temperatures. The temperatures necessary for such reaction are of the order of millions of degrees and can only be produced by a fission bomb; the hydrogen bomb must thus be triggered by a fission bomb. It is fairly certain that hydrogen is the main material for a thermonuclear bomb, for the fusion of heavier elements requires much higher temperatures and produces less energy; but ordinary hydrogen is not suitable, and either deuterium or tritium have to be used.

The main advantage of the hydrogen bomb is that there is no essential limit to its size. It is a very safe explosive, for it will never go off unless fired by the fission bomb. The latter, on the other hand, is by nature unsafe and goes off the instant it is assembled, which puts a practical limit to its size. The load capacity of modern aircraft would, however, limit the explosive power of the hydrogen bomb to about a thousand times that of the fission bomb. The radius of damage of such explosive would thus be ten times greater than that of a fission bomb, that is, about ten miles for severe damage.

Against the background of Nature, atomic weapons are small. An average local thunderstorm releases as much energy as a plutonium bomb; a hurricane or an earthquake, a million times as much. Nevertheless, they are frightful weapons, capable of inflicting terrible destruction and wholesale death.

* Summary of a lecture by Prof. O. R. Frisch, O.B.E., F.R.S., being the second of the series of public lectures arranged by the Atomic Scientists' Association and the Department of Extra-Mural Studies of the University of London (see *Nature*, February 27, p. 386).

MANAGEMENT OF PUBLIC CORPORATIONS

THE Select Committee appointed in December 1951 "to consider the present methods by which the House of Commons is informed of the affairs of the Nationalized Industries and to report what changes, having regard to the provisions laid down by Parliament in the relevant statutes, may be desirable in these methods" issued last year a second report* which indicates very clearly how far we yet are from a satisfactory solution to the problem of parliamentary accountability. The Committee's first report was confined to the Parliamentary 'question' and stressed the limitations of this method of keeping Parliament informed and securing public accountability, rather than offering a fresh contribution towards the solution of what is increasingly recognized as a problem of national importance. In this first report, it was apparent from the evidence submitted to the Committee that, while the importance of the public issues involved is widely appreciated, there is also a considerable difference of opinion as to the means for improving the present unsatisfactory situation, and also some misunderstanding as to the possibility of reconciling in a practicable way the independence and flexibility which are essential if a public corporation is to be characterized by initiative and enterprise, with complete answerability to Parliament.

This is also characteristic of the Select Committee's second report. The clash of opinion is no less marked, and the Committee's recommendations are obviously contrary to the opinions, strongly held and sometimes vehemently expressed, of important witnesses. The value of the report may well lie in the material for critical examination and further constructive thinking which it affords in its minutes of evidence, rather than in its somewhat tentative recommendations. The most encouraging feature of the report is, in fact, the indication it supplies of a disposition to examine the whole problem objectively and to keep

* Report from the Select Committee on Nationalized Industries, together with the Proceedings of the Committee, Minutes of Evidence and an Appendix. Pp. xviii+118. (London: H.M. Stationery Office, 1953.) 4s. net.

criticism of the nationalized industries of Great Britain as free as possible from party politics.

To the reality of the general desire for more information about the nationalized industries the report freely testifies: this is essential for informed and constructive criticism. The Select Committee was equally concerned that the nationalized industries had insufficient opportunity of presenting their case to Parliament and the public, and were exposed to public pressure in various ways and to much irresponsible criticism. Lord Hurcombe, as well as Mr. Hugh Molson, parliamentary secretary to the Ministry of Works, gave evidence on this point; such arguments, and the need for accountability arising from the vast amount of capital and of income and expenditure involved in concerns which are under public ownership, and the direct impact of their charges upon everyday civilized life, quite apart from the Treasury guarantee of interest paid on their stock, led the Committee to consider the appointment of a Standing Committee of the House of Commons or of both Houses of Parliament to examine the nationalized industries and keep Parliament informed upon them.

The arguments for such a committee were advanced by Mr. Molson in his evidence, on the assumption that it would be concerned with elucidating fundamental problems of policy. Mr. Molson was evidently also of the opinion that such a committee would afford Parliament the means, from time to time, of taking stock of the situation, in much the way that Mr. Herbert Morrison had urged in 1950 in suggesting a periodic committee of inquiry at about seven-yearly intervals for each public corporation. Lord Hurcombe, who also supported the suggestion, thought that apart from helping to meet the legitimate demand of Parliament for further knowledge, the continuity of personnel on such a committee could contribute not merely to informed debate, but also to objective debate and to the removal of a controversial atmosphere so that constructive suggestions could be more readily made and received.

Strong representations were made in evidence to the Select Committee that the establishment of a permanent committee of inquiry into the nationalized industries would be both contrary to the spirit and intentions of the acts under which the industries were nationalized and also an innovation in, and hostile to, the general pattern of the British constitution. Lord Reith suggested that the appointment of such an *ad hoc* select committee was in effect a negation of Parliament's deliberate renunciation of the right of direct interference when it passed the nationalization acts. He regarded it as tantamount to institutionalizing the Parliament question and likely to lead to a direct collision between the industries and Parliament.

Although Lord Reith was strongly of the opinion that if any committee were set up it should be a committee of both Houses, that would not avoid the difficulties to which Lord Reith directed attention. Moreover, the committee must be an official committee: an unofficial committee is impracticable, because the contacts between the chairmen of the public corporations and Parliament must be upon an official basis. Lord Reith's own view was that a Royal Commission with wide terms of reference would be a much more effective means of achieving the desired purpose, and he elaborated the argument he advanced before the Public Accounts Committee three years ago as well as earlier. Failing this, he suggested that there might be some minister responsible for the public corporations and provided with a small staff for the purpose, in much the same way as the Lord President of the Council is responsible for the work of the Medical Research Council, the Advisory Council for Scientific and Industrial Research and other bodies.

Lord Reith did not recommend the appointment of such a minister. He merely indicated that it was one way of dealing with the problem, and it was quite clear that such a proposal would still have to solve the difficulty of the parliamentary 'question' if control over day-to-day management is not to develop. He was obviously impressed with the possibility of a Royal Commission reaching a more satisfactory solution and providing constructive proposals on the basis of much more careful study and far-reaching objective inquiry than the complex and important issues involved had as yet received. The Select Committee was obviously impressed with Lord Reith's view and particularly the possibility it offered for more searching inquiry by fresh minds, not limited necessarily to Parliament itself. Nevertheless, in spite of similar arguments advanced by Mr. Herbert Morrison, its own recommendation was for the appointment of a Standing Committee and one of the House of Commons only.

Mr. Morrison did not specify a Royal Commission, but equally had in mind the advantage of a commission which was not limited to members of Parliament and which would be periodic rather than permanent. He emphasized that the responsibility for efficiency should lie on the industries themselves, and suggested that co-operation among the national boards might lead to the establishment of a common efficiency unit which would avoid the dangers inherent in one established for a particular corporation. Moreover, Mr. Morrison raised an objection to the proposed Standing Committee which went deeper and obviously impressed the Select Committee. He recognized that there is also a danger that, by further increasing the duties of Parliament, the efficiency of Parliament itself would be impaired: he was dubious as to whether Parliament is the appropriate body to consider closely the actual management of a complex industrial concern, but he was equally concerned that Parliament as well as the public corporation might break down.

There is much to reinforce Mr. Morrison's concern and to suggest that without further decentralization the working of the whole Parliamentary system of Britain may be endangered. Like Lord Reith, he saw clearly that the appointment of a Standing Committee, no matter how carefully its terms of reference were drawn, must raise afresh the whole question of the responsibility for managing and directing the operations of the public corporation. Accountability itself might well become less certain or secure, and as Lord Reith pointed out, a select committee which started as a friendly communicative body might end by investigating and controlling.

The main argument against the Select Committee's recommendation is, however, as the Committee itself admits, that the proposal would impede the working of the nationalized industries and destroy initiative in them. Mr. Morrison, for example, was apprehensive that the existence of such a Parliamentary committee would encourage exactly the conventional, unadventurous type of mind, with its reliance on routine and precedent characteristic of government depart-

ments which Parliament wished to avoid when it created public corporations. Sir Geoffrey Heyworth, chairman of Unilever, Ltd., and a part-time member of the Coal Board, was no less concerned that such a committee might be led inevitably into inquiries on wide decisions of policy, with repercussions that would discourage initiative and the taking of decisions. Any form of detailed control was likely to entail mediocrity or worse, and he looked rather to the public corporations settling down in due course as integrated bodies and developing their own internal controls and their own adequate relationships with the outside public. The more they could develop into autonomous units the better the chances of success.

Sir Geoffrey Heyworth did not conceal the probability that integration might take a very long time. He recognized, too, that autonomy and responsibility to Parliament are scarcely consistent, and it is perhaps natural that a Select Committee should give the greater weight to Parliamentary responsibility. Having rejected any extension of the Parliamentary question as impracticable, the Select Committee reached the conclusion that the only means of providing Parliament with the desired further information for parliamentary accountability was by means of a Parliamentary Committee. Although some witnesses, like Capt. Crookshank and Lord Hurcombe, were in favour of a committee of both Houses of Parliament, and the practicability and even the advantages of such a committee were admitted by Sir Edward Bridges in his evidence, the Select Committee rejected this suggestion and proposed to exclude members of the House of Lords on the rather slender grounds that some of the work of the proposed committee would be of a financial character.

The Select Committee reached this decision with some regret, and the point is one that merits reconsideration in view of the admitted advantages which wider membership would afford. Moreover, it is clear that in its present form the Select Committee's proposal is concerned with the wider context in which the policy of the corporations is determined and not simply with the inquiries into accounts such as the Committee of Public Accounts makes in respect of government departments. The hope is expressed that the proposed committee's dealings with the Boards will lead the Boards to regard it as a body which they can approach to explain their policies and their difficulties. It is strongly recommended that the committee should avoid the investigation of matters which fall into the category of detailed administration.

The Select Committee's proposal is thus for something more than a committee authorized to conduct those inquiries from which the Committee of Public Accounts is debarred. Although the proposed committee would be provided with staff, including an officer of the status of the Comptroller and Auditor General, and it is suggested that the statutory auditors of the corporations, in preparing their annual reports, should give such further information "as may be of use to the Committee and of interest to Parliament"; provided the approach does not differ too widely from those of ordinary professional auditors, the committee has obviously much the same kind of body in mind as the late Lord Lindsay of Birker suggested in a debate on the nationalized industries in 1950. It is anxious to establish friendly and informal relations between the committee and the various boards, though it does not contemplate anything quite so intimate as the Advisory Board, on the model of the University Grants Committee, which Lord Lindsay then suggested.

The Select Committee comments on the limitations which the increasing calls upon the available time of members of the House of Commons place upon any investigation of the nationalized industries by a committee of that House or any sub-committees it may establish. In spite, however, of leanings towards Mr. Morrison's idea of a septennial commission, or Lord Reith's advocacy of a Royal Commission, it does not appear to recognize that this limitation strengthens the argument for bringing in experienced minds from outside the House of Commons. It is content to recommend in effect merely the establishment of a body which will do for the nationalized industries much what the Committee of Public Accounts does for the Departments of State.

The expediency or practicability of such closer financial accountability or the manner in which further information regarding the accounts of the nationalized industries should be supplied to Parliament and to the public is not the vital issue to-day. The purposes of nationalized industry are economic, but it will not be sufficient merely to ensure that the industries are economically efficient: the suspicion or belief that they are inefficient and uneconomic must be dispelled, and the real difficulties arise because we are dealing in a democracy with a system of State-owned monopolies in an economy that is partly free. The information required is such that will give public confidence that monopoly is not abused, or that any abuse will be promptly rectified. Moreover, while the criteria of efficiency have yet to be established, even on practical considerations problems of organization such as size and decentralization have as yet reached no final solution. But, above all, the nationalized industries are differentiated from earlier experiments with the public corporation by the extent to which their policy impinges on public policy. Only within limits can their policy be determined autonomously: inevitably it is determined broadly and to a varying degree by decisions which the Government itself must take. When, as in the matter of fuel, either Minister or Government fails to produce a policy, the responsibility for lack of initiative or co-ordination must still largely rest upon the Government.

On this ground alone, the Royal Commission which Lord Reith advocates so strongly has much to commend it. The meaning of public accountability where the nationalized industries are concerned is still too vague for more than tentative proposals for achieving it to be formulated, and there is neither general agreement as to the exact purposes to be served nor any clear conception as to those purposes. It might well be found, for example, that even if the internal efficiency unit which Mr. Morrison advocates proved practicable, it would yield no substantial advantage commensurate with the effort. The studies which have already been made by the Acton Society Trust have to some extent cleared the ground, but much more is still required in the way of such objective examination; the slackening of Party conflict over the issue may well encourage a wider examination of the many complex issues involved in the decision as to the most appropriate means by which Parliament and the public can be satisfied that the public corporations in general are efficiently run and the public interest truly served.

LABORATORY ANIMALS BUREAU

THE Laboratory Animals Bureau, a unit of the Medical Research Council housed at the Council's laboratories at Holly Hill, Hampstead, London, N.W.3, has published Vol. 1 of its "Collected Papers"*. As Dr. H. J. Parish explains in his foreword to the volume, the Bureau was established in 1947, and its first director was Prof. R. E. Glover, who is now professor of veterinary pathology in the University of Liverpool. After a vigorous start on its useful career under Prof. Glover's experienced guidance, the Bureau is now directed by Dr. W. Lane-Petter, and most research workers who use experimental animals know the work of the Bureau so well that its value needs no emphasis. There will, nevertheless, be many who will welcome the information contained in this volume.

In the first article, Dr. W. Lane-Petter discusses the problems with which the Bureau has to deal, the uses to which experimental animals may be put, the sources of their supply, the problems of procuring them and of maintaining adequate supplies of them, and certain special problems, such as the provision of uniform strains and animals free from infections.

When, however, these problems have been overcome, the further problem remains of managing and properly feeding the animals in the laboratory, and Prof. A. N. Worden deals with this subject of diets and management in an article based on his experience and special study of the subject. Mr. A. E. Mundy, secretary of the Laboratory Technicians Association, which was founded in 1950 to improve the training and status of the assistants who do the important work of looking after laboratory animals, discusses the functions of these assistants, who are, as every research worker will agree, essential factors in all schemes of research which must employ experimental animals. Mr. J. Scarnell discusses the equally important subject of the control of infections of laboratory animals with diseases which may suddenly wreck experimental work. In an article on the provision of animals for research, Dr. J. S. Paterson, of Porton, gives, from his wide experience of both research and the provision of animals for others, a valuable account of the various problems that arise. He discusses the functions of breeders and dealers and the accreditation scheme for commercial breeders that is supervised by the Laboratory Animals Bureau. The Bureau proposes to issue "Collected Papers" each year, and material for inclusion in it may be submitted to the director.

The Bureau has also issued a "Catalogue of Uniform Strains of Laboratory Animals maintained in Great Britain"†. The Catalogue contains details of the origin, pedigree, description and methods of management of laboratory animals maintained in Britain which are "thought to show a reasonable degree of uniformity". It is not claimed that this is a complete list for the whole country, but it is hoped that laboratories that have not yet sent in contributions to the Catalogue will do so in the future. Strains kept by commercial breeders will also be included if they qualify for inclusion. As the Catalogue says: "A useful degree of uniformity is an essential criterion. Hence many of the strains listed are not strictly inbred, but are random mated in closed population and found by those maintaining them to be sufficiently uniform for their purposes. Whether or not strict sib-mating would increase the degree of uniformity to such a degree as to justify the additional trouble involved is an open question. The answer probably lies in the use to which the animals are to be put. But there can be no doubt that the conditions of management are profoundly important and it is for this reason that much space in the Catalogue is taken up by providing such details."

A feature of these two publications is the picture they give of the humane spirit in action, not only on behalf of the animals with which the Bureau is concerned, but also against disease and the suffering it causes to man and other animals. They also show the valuable results that come when medical men and veterinarians work together in what is, after all, a common field of beneficent activity.

G. LAPAGE

* Laboratory Animals Bureau. Collected Papers, 1953. Vol. 1. Pp. 66. 5s.

† Catalogue of Uniform Strains of Laboratory Animals maintained in Great Britain. Pp. iii+70. 2s. 6d.

(Laboratory Animals Bureau, M.R.C. Laboratories, Holly Hill, London, N.W.3; 1953.)

POPULATION OF LONDON, 1951

THE first of the "County Report" series of tables based on the 1951 Census covers the Administrative County of London*. The tables relate mainly to the numbers, distribution according to age, sex and marital condition of the population of the county, and to the structure of the private households and the conditions in which they were housed. In addition, there are tables relating to birthplace and nationality and to the "Social Class" distribution of the male population. Separate figures are given for the City of London and the twenty-eight metropolitan boroughs. Statistics relating to occupations, fertility and other matters on which information was obtained at the Census are not included in the County volumes but will be published in a series of special reports.

The present volume is of general interest as providing a summary account of some of the social changes which have occurred in London during the past twenty years. Many of these changes were either directly due to the Second World War or greatly accelerated by it. The continuous decline in the population of the Administrative County which began between the 1901 and 1911 Censuses has continued. The total population enumerated in the 1951 Census was 3,347,982 as compared with 4,397,003 at the 1931 Census. The estimated resident population of Greater London, however, increased slightly between these Censuses, the proportion in the outer ring having increased from 47 to 60 per cent of the total. The decline in the population of the inner area has been unevenly spread over the various metropolitan boroughs; the weighted average per cent decline was 23·9 per cent, but Poplar, Shoreditch and Stepney lost more than 50 per cent of their 1931 populations, whereas Hampstead, Lewisham and Woolwich gained 7, 3·5 and 0·7 per cent, respectively.

The reduction of the total population and its unequal incidence in different parts of the County, and the unequal incidence of enemy bombing and post-war building have combined to modify the pattern of housing conditions which existed in 1931. Crude averages representing percentages of total population living at given numbers per room may be misleading indicators of the extent of overcrowding.

* General Register Office. Census 1951, England and Wales. County Report, London. Pp. 1+90. (London: H.M.S.O., 1953.) 22s. 6d. net.

Nevertheless, it is interesting to see that the percentage of all persons living at more than two per room in the whole County was 2·55 per cent in 1951 against 13·13 per cent in 1931. Some remarkable re-ranking has occurred among the boroughs in respect of this index. The highest figures are recorded in Paddington, Kensington and St. Pancras, whereas in 1931 the worst conditions were found in Finsbury, Shoreditch and Bethnal Green. In general, the rank correlation between the indexes for the two years is fairly high.

The 1951 Census sought to obtain some wholly new information about housing conditions by asking questions about certain household arrangements. The results for London are presented in tables showing (separately) the percentage of households having exclusive use, sharing or being entirely without piped water, cooking stove, kitchen sink, water closet and fixed bath. It is not certain that the results of the new inquiry have come up to the expectations of the designers of the census form either on statistical grounds or as sources of unambiguous information about social conditions in different areas: statistically, the value of the results has apparently been somewhat impaired by misunderstanding of the questions on the part of householders; and sociologically, it appears that the results need to be interpreted in the light of other information about household structure. It is, in fact, not nearly as easy as might have been supposed to decide whether relatively extensive sharing of facilities, or even their absence, is an unambiguous sign of poor social conditions in any given area. Some form of factor analysis might be useful in determining significant criteria from this new material. The new tables showing the distribution of heads of households by age, sex and marital condition might prove specially useful in that connexion.

The report contains tables of the percentage of the male population aged seventeen to nineteen in the various boroughs who were engaged in full-time education. They range from 30 per cent in Hampstead to 1 per cent in Shoreditch, and the figures are highly correlated with the percentage of occupied males in the boroughs who stated their "terminal education age" as being seventeen years or more. The boroughs with high "secondary education" percentages tend also to be those with high proportions of professional workers and those with relatively high proportions of residents from outside London.

FLAX IN NEW ZEALAND

NEW ZEALAND has a native plant, *Phormium tenax*, the leaves of which yield a useful cordage fibre, long known in New Zealand as 'flax' and in commerce as 'New Zealand flax'. This fibre is very different from true flax, the bast fibres from *Linum usitatissimum*. The confusion of terms was immaterial before 1940, but in that year New Zealand began to grow crops of the true flax, designating it 'linen flax' to differentiate it from the native fibre. Outside New Zealand it is now customary to refer to the native fibre as 'Phormium' fibre or 'New Zealand hemp'—'hemp' being used as a general term to include all the cordage fibres, while the original hemp fibre from *Cannabinus sativa* is described as 'true hemp'.

In Great Britain, as a consequence of the cutting off in 1940 of flax supplies from the Continent of Europe, the Ministry of Supply appealed to New Zealand to grow fifteen thousand acres of flax to help fill the gap. The response was prompt, favourable and energetic. Fortunately, three years before the War the New Zealand Department of Scientific and Industrial Research had arranged for the officers of its Agronomy Division to make investigations of flax growing and processing in association with the Fields Division of the New Zealand Department of Agriculture; and when the crisis came, the officers were able to advise with confidence where and how the flax could be grown, and what yields of fibre and seed might be expected. But no organization was in being; in so novel a situation the difficulties were immense, for the farmers had no knowledge of the flax crop and the engineering firms had no experience of making the processing machinery. The problem was threefold—to establish an industry, to grow the crop and to process it; and the problem was successfully solved, the success being due to splendid team-work.

A report of how all this was done has been prepared by Mr. J. W. Hadfield, formerly director of the Agronomy Division, N.Z. Department of Scientific and Industrial Research*. To start with, a Linen Flax Management Committee was set up, to which Mr. Hadfield was seconded as director of linen flax production. It was arranged that the Department of Agriculture should organize and control all field operations, the arranging of contracts, sowing and harvesting; that the Marketing Department should handle the export of fibre, tow and seed; and that a Linen Flax Section should be established under the Department of Industries and Commerce to erect mills and carry out all factory operations. The co-operation was secured of the Public Works Department, which undertook the purchase of sites, letting tenders, and supervising the construction of factory buildings and retting tanks. The machinery problem was solved by the help of the Railways Department workshops, which supplied locomotive boilers to the mills and manufactured flax-processing machinery based on European models.

In a few months the new industry was established. The speed with which this co-operative enterprise was developed is revealed by the captions of two photographs in the report: "Instructions to grow flax were received in June 1940. Sowing commenced four months later, and harvesting in January 1941. . . . Flax mills were being built while the crops they were to process were growing. The first fibre was delivered from the mills in March 1941".

Part 1 of the report is a plain record of plans and achievements and describes the fascinating details of how the industry was established, without omitting mention of the inevitable disappointments and criticisms. Part 2 describes the application of the general principles of flax growing to the particular conditions of the seventeen areas in the South Island in which the flax was grown. Part 3 describes the processing methods followed at the mills set up in the various growing areas.

It was inevitable that the hasty but successful improvization of flax production in 1940 should be carried out without immediate regard to cost; more than thirteen thousand acres were actually sown with flax in 1940, and even greater acreages in succeeding years. But after the War, when it became necessary

* Linen Flax Fibre Production in New Zealand. By J. W. Hadfield. Pp. xviii+125. (New Zealand: The Linen Flax Corporation of N.Z., and the N.Z. Departments of Agriculture, Industries and Commerce, and Scientific and Industrial Research, 1953.) n.p.

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The report is not only a permanent record of New Zealand's war effort in flax; it is also a mine of information, well printed, lavishly illustrated with excellent photographs, invaluable as a guide to flax production, and indispensable to everyone concerned with flax in New Zealand. In short, Mr. Hadfield is to be congratulated on a very fine publication, as are all who had a share in bringing to a successful conclusion the flax enterprise with which it deals.

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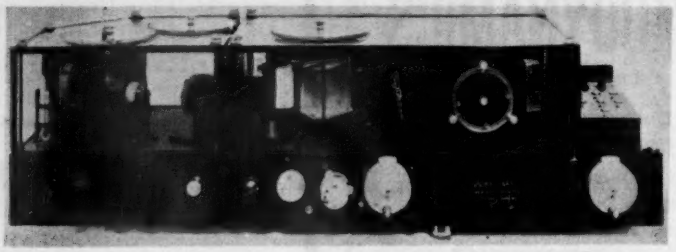

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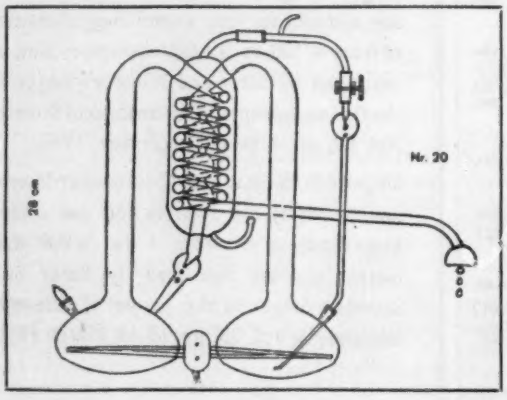

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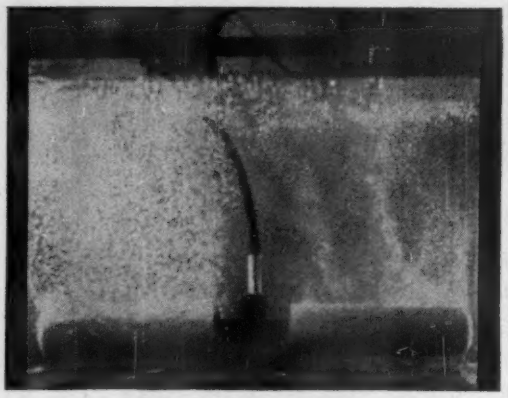

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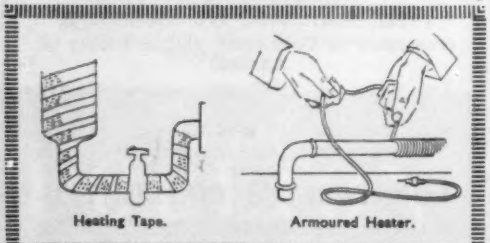

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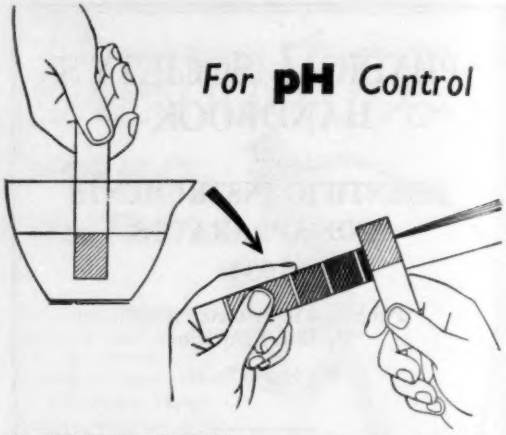

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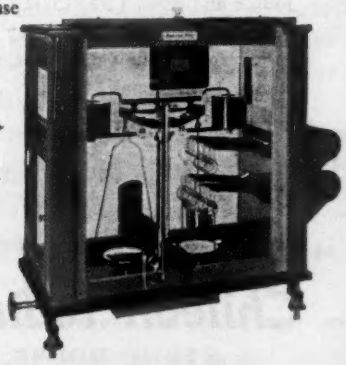

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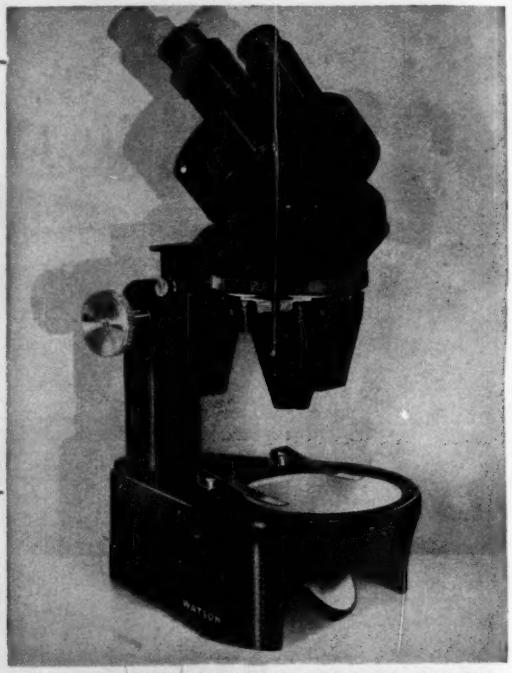

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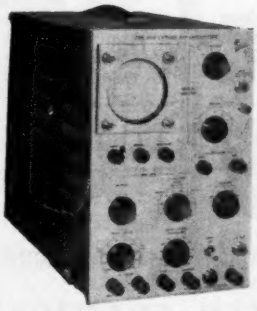

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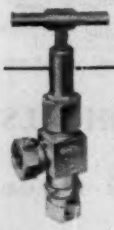

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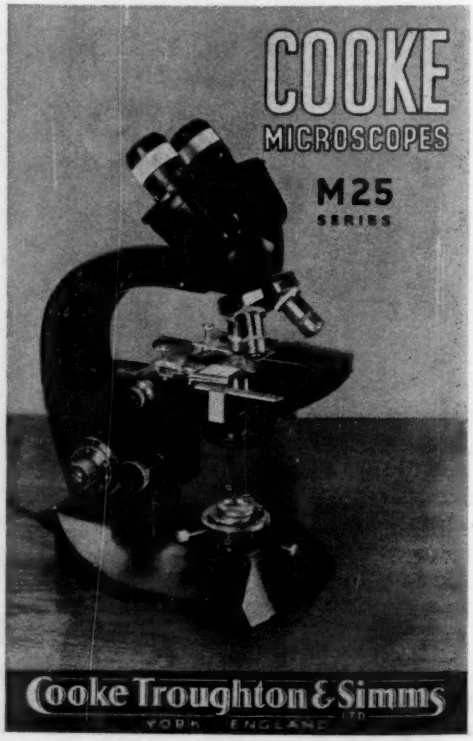

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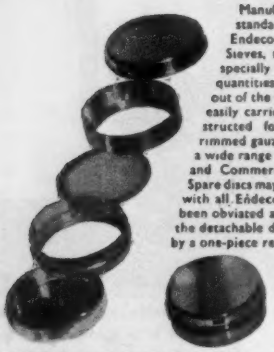

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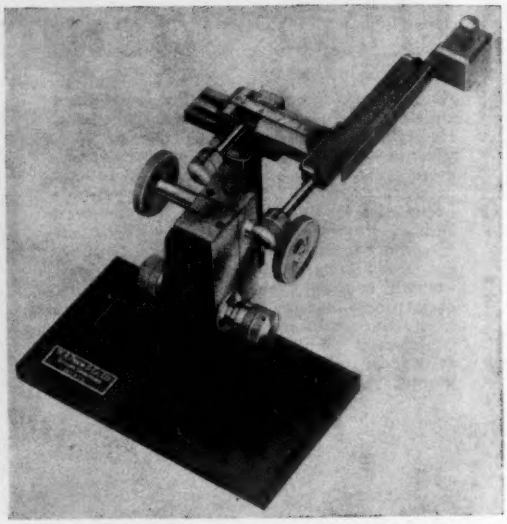

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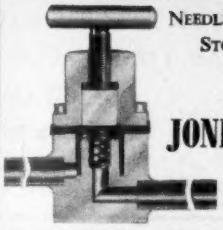

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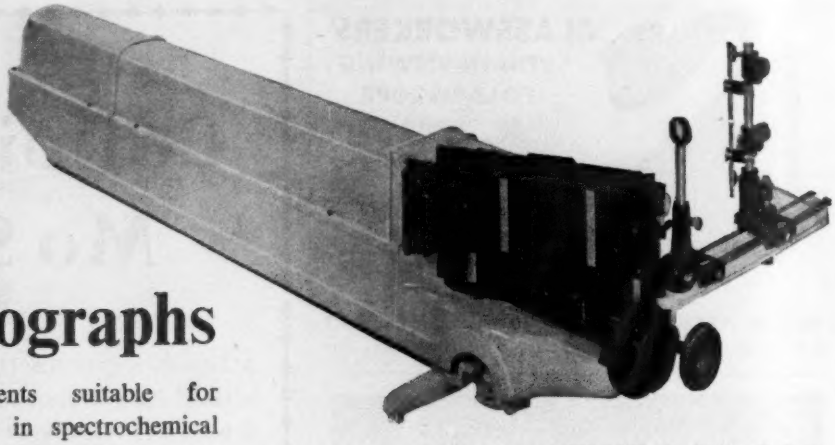

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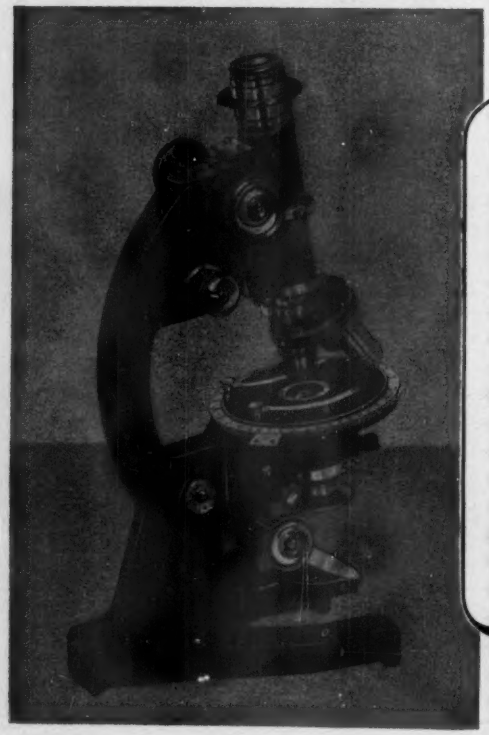

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stellar gas which he considers overcomes both these difficulties. Electron acceleration is provided, not by individual protons, but by local concentrations of space charge. He claims that, if separation of protons and electrons is complete, then emission is increased by a factor $(v/f)^3n$, where v and n are the electron velocity and density. He considers that a factor of 10^8 might be attained and so account for the observed sources in Cygnus, Cassiopeia and Taurus.

The suggestion provides an interesting extension of free–free emission theory. Under suitable conditions, both a negative value of ε and increased emission (above the free–free level) may occur. However, it appears necessary to revise Hoyle's treatment and particularly his conclusions concerning the radio sources.

An error in Hoyle's argument is that he compares his process, not with that of close collisions as in the theory of free–free emission, but with accelerations by small statistical concentrations of charge in volumes of dimensions v/f. Radiation by the latter process is generally so small as to be neglected in free–free theory. The numerical effect of this error is shown by comparing the average emission by a single electron by the proposed process and by free–free emission. First consider an electron moving in a nearly straight line tangential to a sphere of radius b containing n protons per cubic centimetre and no electrons. A pulse of radiation is emitted of duration $\sim 2b/v$ and peak intensity $32\pi^2e^6n^2b^2/27c^3m^2$ erg sec.$^{-1}$, e and m being the electron charge (e.s.u.) and mass, and c the velocity of light. This radiation is spread over a frequency-range from zero to about $f = v/2b$, and so the power per unit frequency interval is about $23e^6n^2b^2/c^3m^2v$ erg sec.$^{-1}$ (c./s.)$^{-1}$. This may be compared with the average power radiated by an electron by free–free emission when the density of protons is also n per cubic centimetre. Such a comparison should rather favour the Hoyle process in the example given, because the electron considered provides the maximum radiation. The majority of electrons will either pass through the sphere of protons or pass it at distances greater than the radius; these will radiate less. Also electrons moving at velocities less than $2bf$ and those passing well outside the sphere have an emission spectrum which is cut off below f and so do not contribute. These effects should more than compensate for the fact that the total number of protons in a given large volume is greater in the free–free than in the Hoyle example given.

The average free–free emission per electron into solid angle 4π is[4] $32(2\pi)^{1/2}A_1(2)e^6n/3c^3m^2v$ erg sec.$^{-1}$ (c./s.)$^{-1}$, where $A_1(2)$ is a factor proposed by Chapman and Cowling to limit the maximum collision distance for which contributions to the total radiation are considered. For an electron temperature of 10^8 °K. and $n = 1$, its value is 52·6 and the total emission is 1,400 e^6n/c^3m^2v. Radiation by the Hoyle process exceeds this by a factor of 0·016 b^3n or 0·002 $(v/f)^3n$ and not the factor $(v/f)^3n$ stated by Hoyle.

When applied to discrete source radiation the theory is found inadequate. For example, the intensity[2] and size[5] of the Cygnus source at 100 Mc./s. indicate an average brightness temperature of 4×10^8 °K. If all the electrons in the cloud have velocities of 10^{10} cm. sec.$^{-1}$, corresponding to a temperature of $\sim 2 \times 10^8$ °K., then the optimum value of b is 50 cm. Assuming a value of $n = 1$ cm.$^{-3}$, then a cloud of thickness (in the line of sight) 10^8 parsecs is necessary to provide optical depth unity and brightness temperature $\sim 10^8$ °K., somewhat lower than that observed. Throughout the whole of this excessively large gas cloud most of the protons and electrons must be grouped in separate blobs which have at least one dimension about 50 cm. Larger or smaller blobs reduce the radiation at the frequency considered. Roughly similar considerations apply for the Cassiopeia source.

The radio source in Taurus warrants special mention because its spectrum, substantially flat[6] from 40 Mc./s. to 1,200 Mc./s., is consistent with a thermal (free–free) origin in optically thin gas. However, such an origin would require excessively high values of electron temperature and density[6] and also of visual radiation[7]. The position is not retrieved by applying Hoyle's theory. The flatness of the spectrum down to 40 Mc./s. indicates a low optical depth and consequently an electron temperature much higher than the brightness temperature; as for free–free emission, an unacceptably high value of $\sim 4 \times 10^7$ °K. is found. The flat spectrum at 1,000 Mc./s. also necessitates proton concentrations of extremely small dimensions—less than 2 cm. in radius for electron velocities corresponding to a temperature of 4×10^7 °K.

Further quantitative difficulties are met in connexion with the method of formation of the space charge concentrations, assumed due to the movement of gas clouds through a magnetic field of strength about 10^{-6} gauss. The maximum electric field which can result is VH/c, where V is the cloud velocity (about 10^8 cm. sec.$^{-1}$) and H the magnetic field. Electrons accelerated in this field (3×10^{-9} e.s.u.) will give only about 10^{-3} of the radiation found above for the Cygnus source. Again, the radius of gyration of a proton in a magnetic field of strength 10^{-6} gauss is about 10^8 cm. for a proton temperature as low as 10^4 °K. The magnetic field could scarcely form space charge concentrations of dimensions less than 10^3 cm. with random movement $\sim 10^8$ cm.

It would seem that Hoyle's suggestion is not acceptable and that some non-thermal process, involving ordered motions of electrons, must be invoked to account for discrete source radio emission as well as for the general background radiation.

I am indebted to Dr. J. A. Roberts, of this Laboratory, for helpful discussions.

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Dec. 2.

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I am indebted to Dr. J. H. Piddington for directing attention to the omission of a numerical factor in a former communication[1]. This arose from the inadvertent use of the usual optical formula for the emission by free–free electronic transitions. This led to the dropping of an important logarithmic factor contained in Dr. Piddington's $A_1(2)$ term. The remaining numerical discrepancy is largely accounted

for by my use of $f \sim v/b$ as an order of magnitude, whereas Dr. Piddington uses $2f \sim v/b$.

Before learning of Dr. Piddington's comments, I had also reached the conclusion that my former suggestion is unworkable, for the reason that I now doubt whether charge separation could occur on a sufficiently fine scale. The smallest unit of distance in an ionized gas is the Debye wave-length λ_D, given by

$$\lambda_D = (kT/8\pi ne^2)^{1/2}, \quad (1)$$

where n is the electron number density and k, T, e have their usual meanings. The regions in which charge separation was supposed to take place (according to the suggestion of my former communication) was less than λ_D by a factor of order 10^2 or 10^3. It is difficult to see how this could occur, since λ_D is apparently the smallest distance over which one element of material can communicate with another.

It would accordingly seem that the point previously noted—that black-body emission would give intensities comparable with the emission intensities of Cygnus A and the Crab—is probably a coincidence.

Turning to non-thermal processes, there seem to be two schools of thought: the plasma oscillation school and the fast-particle school. From Dr. Piddington's last paragraph one would judge that he belongs to the plasma oscillation school. For my own part, I would favour the other possibility. It seems that progress toward an understanding of the cosmic origin of radio waves may be made by a study of synchrotron-type emission by relativistic electrons[2]. This has been discussed by Alfvèn and Herlofson[3], and also mentioned by me[4]. Since then, certain features of the problem have changed; notably, there is now a much greater certainty concerning the physical nature of the radio sources. This makes it worth again mentioning the advantages possessed by a fast-electron theory.

Before doing so, a criticism must be met. Electrons not only seem to be absent from cosmic rays, but also considerations of the type first discussed by Fermi[5] would seem to provide a strong reason why relativistic electrons should not be present in interstellar space, namely, that the rate of energy loss from collisions with the interstellar gas clouds is from 10^2 to 10^3 times greater than the rate of gain of energy through 'magnetic collisions'. It may, however, be possible to overcome this discrepancy. The Fermi acceleration mechanism gives a gain-rate that is proportional to the square of the mean random dynamical velocity of the gas masses that carry the magnetic field. Fermi's original calculations were based on a mean velocity of 30 km./sec. In strong radio sources, such as Cassiopeia and Cygnus A, a velocity of 3,000 km./sec. would be more appropriate, thereby increasing the gain-rate by a factor 10^4—more than sufficient to overcome the discrepancy. It would seem, therefore, that the above-mentioned criticism can be countered. Indeed, the special conditions required for an electron-acceleration mechanism to operate may well prove an advantage, since it apparently explains why the normal interstellar gas is comparatively weak in radio emission and why high dynamical velocities seem always to accompany strong emission, a point that has been emphasized by Minkowski[6].

Turning now to quantitative aspects of the matter[2,3], a relativistic electron of velocity v radiates mainly at frequencies close to the value of ν given by

$$\nu = 4{\cdot}19 \times 10^6 B\gamma^2 \text{ c./s.}, \quad (2)$$

where B, the magnetic intensity, is in gauss, and $\gamma = (1 - v^2/c^2)^{-1/2}$, so that the electron energy is γ times its rest mass. For $\nu = 10^8$ c./s., and $B = 10^{-3}$ gauss, the appropriate value of γ is about 150. The power radiated by a relativistic electron is:

$$1{\cdot}58 \times 10^{-15} B^2\gamma^2 \text{ ergs/sec.} \quad (3)$$

The latter formula implies that a relativistic electron radiates an appreciable fraction of its energy in radio waves in a time of order

$$5 \times 10^8 B^{-2}\gamma^{-1} \text{ sec.} \quad (4)$$

Using the above relation between γ and ν, this may be expressed by saying that an electron radiating a frequency close to ν loses an appreciable fraction of its energy in

$$10^{12} B^{-3/2}\nu^{-1/2} \text{ sec.} \quad (5)$$

Inserting $\nu = 10^8$ c./s., $B = 10^{-3}$ gauss gives a time of about 10^5 years, which, cosmically speaking, is a very short interval—implying that the present process is a powerful one. Furthermore, it can readily be estimated that if the masses involved in the collision of the Cygnus galaxies are $10^{11} \times$ mass of sun, say, and if the total energy of all relativistic electrons now present within these galaxies is only a fraction, 3×10^{-5}, of the total energy of the collision, then an adequate intensity in the radio band is emitted. Thus the emission is not only rapid when considered from the point of view of an individual electron, but also can be a highly efficient converter into radio energy of the dynamical energy of mass motion of cosmic material.

While the value $B = 10^{-3}$ gauss used above may seem high, it must always be remembered that magnetic intensities much above the normal magnetic intensity in interstellar space are to be expected in high-velocity collisions. In such cases greatly compressed fields are likely to be produced.

It remains to add that these ideas can be put to a test. It is possible, given the energy spectrum of the relativistic electrons, to use the above formulæ to obtain the frequency spectrum of the emitted radio waves. Suppose that the number of electrons in the range γ to $\gamma + d\gamma$ ($\gamma \gg 1$) is proportional to $d\gamma/\gamma^3$, this being similar to the normal cosmic ray spectrum. Since each electron emits at a rate proportional to γ^2, it follows that the total emission by all electrons in the range γ to $\gamma + d\gamma$ is proportional to $d\gamma/\gamma$, which by (2) is proportional to $d\nu/\nu$. Hence the frequency spectrum of the radio waves should follow a $d\nu/\nu$ dependence. This may be compared with the observed dependence of about $d\nu/\nu^{1\cdot2}$. The agreement is satisfactory in view of uncertainty in the energy spectrum of the electrons.

It is a pleasure in conclusion to express my thanks to Dr. Leverett Davis for a valuable discussion on the subject-matter of the later sections of this letter.

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LETTERS TO THE EDITORS

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Phototropy of Chlorophyll Solutions

OXYGEN-FREE solutions of chlorophyll in methanol undergo rapid, reversible photochemical changes if they are exposed to a flash of intense light[1]. The reversible formation of pairs of radicals, which can be detected by the use of steady, comparatively weak illumination[2], is apparently preceded by the efficient photochemical production of chlorophyll molecules in a metastable (presumably triplet) state, having a half-life of about 5×10^{-4} sec. Since the experiments, upon which the foregoing conclusions[1] were based, were incomplete and, in many respects, preliminary in character, it was thought worth while to attempt to confirm and to extend them using the method[3] of flash photolysis and flash spectroscopy.

The apparatus and techniques were similar to those used by Porter and Windsor[4] in their investigation of solutions of aromatic hydrocarbons. The purified samples of the chlorophylls and the phæophytin *a* were prepared by Mr. K. Owens at the Department of Chemistry, University of Minnesota. The coproporphyrin tetramethyl ester was kindly given by Dr. Schwartz, of the School of Medicine, University of Minnesota. The several solvents were of commercial origin, of 'Analar' grade when it was available, and were used without further purification.

As is illustrated by Fig. 1, the normal ground-state absorption of these pigments is almost completely absent when the spectrum of the solution is observed immediately after a photolytic flash. While some new regions of absorption appear after flash illumination of solutions of the chlorophylls or of coproporphyrin, the more obvious change in the absorption spectra is the result of the depopulation of the ground-state. Solutions of phæophytin *a* exhibit the reverse effect; a $4{\cdot}5 \times 10^{-6}$ *M* solution of this pigment in its triplet state is practically opaque throughout the visible ($\lambda < 5800$ A.) and near ultra-violet regions.

Not only were the energies of these flashes comparatively small (125 joules or less), but, in addition, an important fraction of the actinic light was absorbed by the 'Pyrex' walls of the cells which contained the solutions. In a few experiments the energy of the flash was reduced to 75 joules without any appreciable decrease in the photochemical effect. Indeed, quantitative comparisons of the absorption spectra obtained by means of photographic flashes only with the corresponding spectra obtained with weak steady light showed that the photographic flash itself converted a detectable (5 or 10 per cent) fraction of the normal molecules into their triplet states.

The photochemical conversion of chlorophyll into its triplet state is at least as efficient in benzene as it is in methanol. This is in marked contrast to the steady-state formation of the radicals, which occurs[2c] detectably in methanol, acetone, etc., but not when benzene is the solvent. In the preparation of one solution of chlorophyll *b* in benzene (for which we are indebted to Dr. W. F. Watson, of the British Rubber Producers Research Association, Welwyn Garden City), an effort was made to dry the solvent and to exclude moisture from the solution. Although this solution showed the expected reduction in the intensity of its fluorescence[4], the efficiency of the photochemical formation of the triplet state was not noticeably decreased. Solutions which were saturated with air exhibited virtually no reversible photochemical response to flash illumination (compare refs. 1, 2 and 4).

Qualitative inspection of the spectrograms indicates that the half-life of the principal photochemical transient, which is formed in degassed solutions of these pigments in benzene or methanol, has a value between 2 and 5×10^{-4} sec. In the viscous solvent *cyclo*hexanol, a metastable form of chlorophyll existed in detectable quantities for several milliseconds after the photolytic flash.

The results reported here are qualitatively similar to those obtained[4] with solutions of aromatic hydrocarbons. They are also consistent with the published[1] interpretation of the phototropic response of methanolic solutions of chlorophyll *b*. A spectral and kinetic analysis of the results, of which that represented in Fig. 1 is a small sample, will be reported elsewhere.

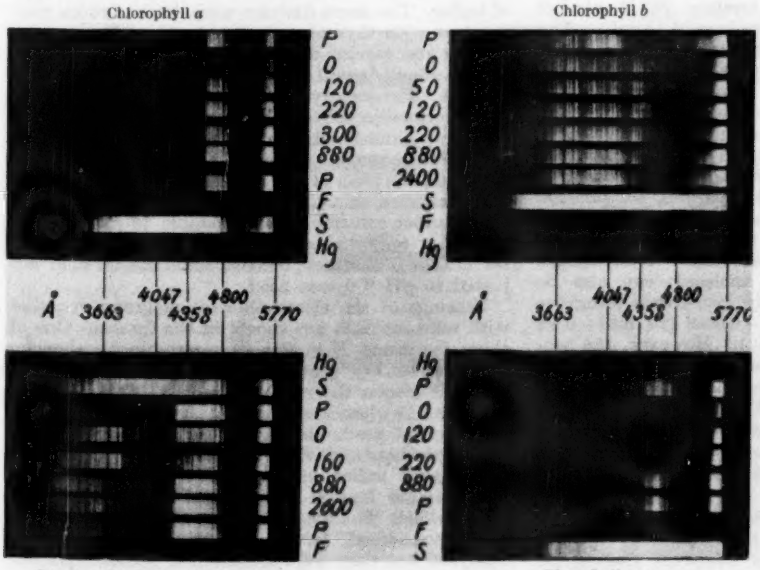

Fig. 1. Series of flash spectra. Numbers are time-intervals between flashes in μsec.; *P* is photographic flash through solution; *S* is photographic flash through solvent, *F* is photolytic flash alone; and Hg is spectrum of mercury – cadmium arc. The solvent was benzene, except in the case of chlorophyll *a*, where it was methanol

This work is consequent to a series of researches which were supported by the U.S. Office of Naval Research (Project 051,028) at the Department of Chemistry of the University of Minnesota. While the present work was in progress, one of us (R. L.) was a Guggenheim Memorial Foundation Fellow on sabbatical leave from the University of Minnesota. We are also indebted to the British Rayon Research Association for a research grant to one of us (M. W.), and for the loan of apparatus used in this work.

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Filter-Paper Chromatographic Analyses of Phosphate Mixtures

Previous papers[1,2] from these laboratories described a filter-paper chromatographic procedure for separating and determining the various components of phosphate mixtures. Improved filter paper (Schleicher and Schuell No. 589 Black- and Orange-Ribbon) and other changes have materially increased the accuracy and extended the range of components separated. A revised procedure will be published, but in the meantime an indication of its range and accuracy may be of interest.

Mixtures containing any or all of the following phosphates: ortho-, pyro-, tri-, trimeta-, tetrameta-, are separated into bands by filter-paper chromatography using the solvent tertiary butyl alcohol (80 ml.) – water (20 ml.) – formic acid (5 ml.). The blue phosphomolybdate colour is developed by ultraviolet irradiation. The amount of phosphorus in each band is then determined by a modification[3] of the colorimetric procedure described by Boltz and Mellon[3]. Phosphate components of chain-length greater than four phosphorus atoms per molecule remain on the starting line and are grouped together for analytical purposes. The various components are determined with a standard deviation of 0·8 regardless of the percentage present.

Phosphate mixtures of components with one to nine phosphorus atoms per molecule can also be separated chromatographically into bands using the solvent *n*-propanol (60 ml.) – water (20 ml.) – 0·88 ammonium hydroxide (20 ml.). However, the separation is not so clearly defined and thus the analyses are not considered to be as accurate, even though the precision is ± 1 per cent. The accuracy cannot be checked since pure samples of these polyphosphates are not available at present.

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Electrophoresis of Group-Specific Extracts of Streptococci

While it is known that differences in the make-up of large molecules can be detected immunologically when the molecules are chemically and physically indistinguishable, it is also true that different groups of bacteria show many differences besides their immunological reactions. It is to be anticipated that the hydrochloric acid extracts which are used as antigens in precipitin reactions will be complex mixtures, and though they show the characteristic immunologically specific reactions it will not be surprising if grosser differences appear. The number and electrophoretic behaviour of the colloids present may constitute such differences. This was tested by examining extracts of nine strains from five serological[1] groups of streptococci. The strains were 28/*USA* of Group *A*, *C*104 and *NCTC*8181 (*Streptococcus agalactiae*) group *B*, Pearl 11 (*Str. bovis*) and 775 (*Str. faecalis*) group *D*, *C*24*B* and 4678 (*Str. infrequens*) group *E*, and *H*14 (*Str. lactis*) and *H*19 (*Str. cremoris*) of group *N*[2].

Hydrochloric acid extracts were prepared by the method of Lancefield[1] and were concentrated by ethanol precipitation; their specificity was established in precipitin ring tests with immune sera for each of the relevant serological groups. The precipitin tests were made by Shattock's[3] technique and were read repeatedly between 1 and 10 min., and the negatives again after 15 and 30 min.

The extracts were submitted to electrophoresis by the usual free-boundary technique. The electrophoresis of the first batch of extracts (Fig. 1) was carried out in 0·01 *M* potassium phosphate, *p*H 8·4, containing lithium chloride at a concentration of 0·05 *M*. The precipitates from the ethanol treatment were suspended in the buffer and allowed to dialyse in 'Visking' tubing against the same buffer for a minimum of forty-four hours with at least three changes of buffer. The short dialyses were done at room temperature with thymol as a preservative. Frequently, dialysis was carried on for longer at 10° C. or below.

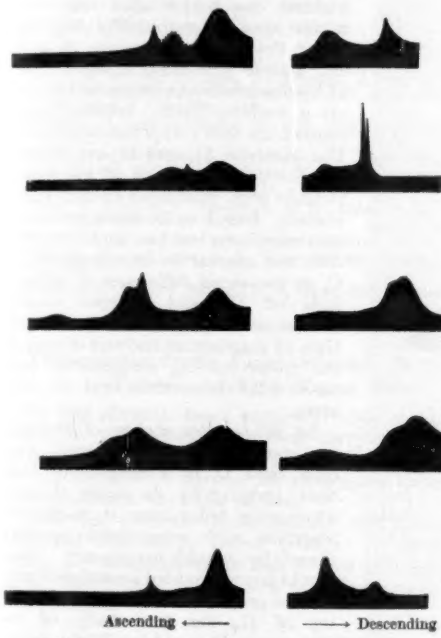
Occasionally small amounts of precipitate failed to dissolve. Frequently, the solutions were opalescent. They were subjected to a thorough centrifuging, which, however, diminished the opalescence only slightly. The electrophoretic diagrams were therefore of low contrast; one peak in this set was difficult to interpret (this has been shown with a serrated edge in Fig. 1) and another solution was impossible to analyse.

Similar remarks apply in general to the second set (Fig. 2), in which 0·05 *M* aminoacetic acid adjusted to *p*H 9·0 was used.

Tracings of the electrophoresis diagrams together with relevant data are shown in the figures. One of those for group *E* in Fig. 2 is notable for showing negative density gradients on the descending side. For this reason the run was stopped after only ten minutes. The buffer conductivities for the calculation of potential gradients have been determined since the experiment. Rough measurements carried out at the time indicated that in the glycine buffer all the extracts had a higher conductivity than the buffer alone. The diagrams show that the conditions were not ideal for quantitative electrophoretic analysis, but they were maintained because qualitative differences may sometimes be observed more easily under such conditions[4].

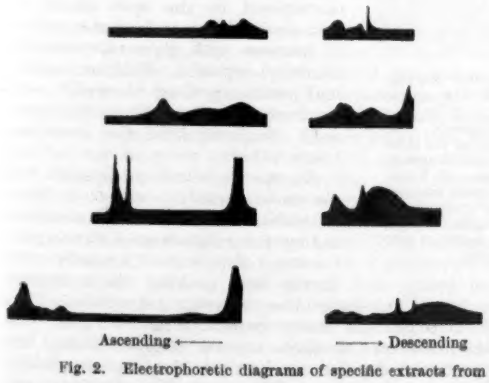
It may be seen from the figures that interesting differences in the electrophoretic pictures occur,

though group differences as opposed to strain differences are not immediately apparent. It is clear that many more comparisons would be needed to recognize these, if, indeed, they do actually exist. Electrophoresis may, however, be of greater value in the differentiation of groups of bacteria less closely related than the streptococci.



Group	Strain	Field-strength V (volts/cm.)	Duration T (sec.)	$\frac{VT}{1,000}$
N	*H14*	1·4	4,920	7
N	*H19*	0·93	4,980	5
B	*N.C.T.C.* 8181	1·4	4,320	6
B	*C104*	1·4	5,460	8
A	*28/USA*	1·4	1,920	3

Fig. 1. Electrophoretic diagrams of specific extracts from streptococci of groups *N*, *B* and *A*



Group	Strain	Field-strength V (volts/cm.)	Duration T (sec.)	$\frac{VT}{1,000}$
E	*C24B*	0·135	600	0·08
E	4678	0·135	1,680	0·2
D	Pearl 11	0·36	1,920	0·7
D	775	0·45 0·225	1,020 1,260	0·7

Fig. 2. Electrophoretic diagrams of specific extracts from streptococci of groups *E* and *D*

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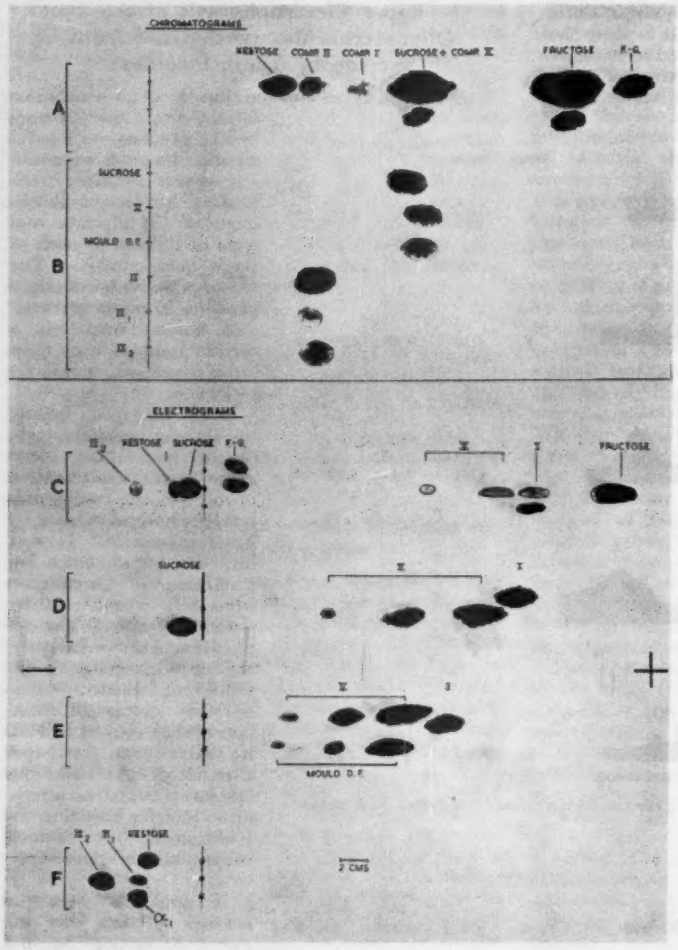
Paper Electrophoresis of the Oligosaccharides synthesized from Sucrose by Yeast Invertase

The interesting suggestion that the oligosaccharides formed from sucrose may be the precursors of polysaccharides such as inulin and levan requires verification by the establishment of the identity and type of linkage of each of these compounds[1]. The recent discovery of their presence in plant extracts[2] and human urine[3] is a certain indication of their significance in metabolic processes.

Good progress, mainly by chromatographic techniques, has latterly been made in the identification of most of the compounds produced from sucrose by yeast invertase[4]. It was, however, found that a few problems of separation were left unsolvable by chromatography. The application of the recently described[5] high-voltage technique of electrophoresis to this group of compounds has proved a definite advance on the paper chromatographic technique and has provided an alternative tool for checking the homogeneity of 'chromatographically pure' fractions.

Incompletely hydrolysed sucrose solution was prepared according to our procedure[6] and diluted to one-tenth of the original concentration before application to the paper strip. The accompanying figure illustrates results obtained by the electrophoretic technique in comparison with the paper chromatographic method. The electrogram *C* shows eight distinctly separated spots, while the chromatogram *A* shows only six spots. Under our conditions of incubation component IV was not formed in any detectable quantity. Throughout this communication the nomenclature suggested by previous workers[7,8] is followed.

It had been observed[9] that on chromatograms the sucrose spot obscured another spot representing component V, which was detected by its reducing power and appeared to consist of two fructose residues. The leading edges of a number of sucrose spots were therefore extracted with water and subjected to paper electrophoresis. On development



Electrophoresis of oligosaccharides. (*A*) Chromatogram of a sucrose solution incompletely hydrolysed by yeast invertase. Conditions: 5 μl. of 50 per cent (w/w) sucrose sol. run for 48 hr. with mixture *n*-propanol – ethyl acetate – water (7 : 1 : 2, by vol.) sprayed with α-naphthol and phosphoric acid for ketose-containing compounds. *F.G.* is fructosyl–glycerol. (*B*) Chromatogram of some oligosaccharides run under the same conditions. Mould *D.F.* is an assumed difructose-compound produced by mould invertase. (*C*) Electrogram of incompletely hydrolysed sucrose solution. Conditions: 40 V./cm. 20–28 m.amp. Whatman No. 3*MM*, 2 × 22½ in. strip, 0·05 *M* sodium borate solution, *p*H 9·2, 5 μl. of 5 per cent (w/w) hydrolysed sucrose solution applied 6 in. from cathode end, 3 hr., same spray as in (*A*). (*D*) Run under the same conditions for 2½ hr., 50 μgm. of sucrose. (*E*) Run under the same conditions for 2½ hr. (*F*) Applied in centre of strip and run under identical conditions for 3 hr., 50 μgm. of kestose

ally, there is no distinction between these two 'compounds', as can be seen in *B*.

While examining by electrophoresis the homogeneity of chromatographically separated fractions, it was found that component II yielded one major spot and one minor spot of a mobility slightly lower than that of kestose (*F* and *B*). Bacon[4] succeeded in separating II by the gradient elution technique on a carbon–'Celite' column, and named the two components II_1 and II_2. Kestose, II_2 and II_1 are all trisaccharides. Samples of his compounds were examined electrophoretically, found to be homogeneous, and were later used as controls. II_1 does not appear to be separated in *C*, as the small difference in mobilities of II_1 and kestose would necessitate a considerably longer time of running, at the end of which the faster-moving components will have left the anode end of the strip.

In the earlier stages of the investigation it was assumed not only that II is homogeneous but that, judging by its paper chromatographic behaviour, it might be identical with component α_1 produced by mould invertase[5]. This would have provided a quicker route for the preparation of a large quantity of II_2 for the study of its structure. It could be shown, however, electrophoretically that the mobility of α_1 is distinct from that of II_2 and similar to that of II_1 (*F*). The fastest spot in *A* was found to correspond to the spot ahead of sucrose in *C* and to be a compound of fructose with glycerol, probably fructosyl–glycerol. This component had previously been observed[7], and its formation depends on the presence of glycerol in the invertase preparation.

At the high voltage applied the electro-endosmotic effect is considerable, as shown in *F*, counteracting the migration of the sugar–borate complexes towards the anode and making them appear to travel towards the opposite electrode. This effect might to some extent interfere with the determination of true values of mobilities, but apparently does not obstruct the reproducibility of the separations. Whatman No. 3*MM* paper was found in this case to give the best results with regard to loading capacity and regularity of spots. Although the thicker paper meant higher current values, the cooling system proved to be adequate in dealing with an energy dissipation of 60 watts. With more efficient cooling the final current value was recently limited to 25 m.amp.

Thanks are due to Mr. H. C. S. de Whalley, director of research, for encouragement, to Dr. J. S. D. Bacon of the University of Sheffield for exchange of

with α-naphthol and phosphoric acid a series of three spots could be seen (*D*). The two faster spots correspond to two spots on *C*, while the faint spot is not made visible owing to its low concentration in the mixture applied to *C*. It thus appears that component V is not homogeneous but consists of two major and at least one minor constituent. Their identity has not yet been established. A sample of a difructose-compound produced from sucrose by mould invertase (supplied by Dr. J. S. D. Bacon), when examined electrophoretically, showed a similar pattern of three spots, the only apparent difference being that the second component was present in a far lower concentration (*E*). Chromatographic-

information and gifts of samples, and to the directors of Tate and Lyle, Ltd., for permission to publish this communication.

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Thiaminase from Fresh-Water, Brackish-Water and Salt-Water Fish

It has already been reported[1] that there might exist in fish more than one enzyme possessing thiaminase activity. In view of this observation, it was thought of interest to investigate thiaminases from different varieties of fish.

For the present investigation, the fishes were classified into three broad groups: (i) fresh-water fish; (ii) brackish-water fish; and (iii) salt-water fish. The following varieties (two from each group) were studied.

	Source	Name of fish
1.	Fresh-water fish	Khavale (*Barbus sarana*)
	" "	(*Labeo baggut*) (Sykes)
2.	Brackish-water fish	Vaunshi (*Mugil* sp.)
	" " "	Tol (*Hemirhamphus xanthopterus*)
3.	Salt-water fish	Mandeli (*Coilia dussumieri*)
	" "	Pedve (*Sardinella fimbriata*)

The whole fish was ground in a mortar and the enzyme extracted with water. The extracts were filtered and the filtrates were tested for activity. The effect of hydrogen ion concentration on the inactivation of thiamine by thiaminases from different varieties of fish was studied. The experiments were carried out between *p*H 3·0 and 7·0, using acetate and phosphate buffers respectively. The reaction mixture consisted of 5 ml. of water extract plus 5 ml. of the buffer and 25 μgm. of thiamine. The reaction mixture was incubated overnight for 16 hr. at room temperature (28° C.) with toluene as a preservative. Thiamine left over at the end of this period was estimated by the thiochrome method[2]. The results of typical experiments are shown in Fig. 1. Although six species of fish were examined for thiaminase activity only three are represented graphically for the sake of convenience. The other three species also showed a similar pattern of *p*H activity relationship.

It is evident from the above results that the fresh-water fish contains thiaminase having optimum activity only at *p*H 7·0 or above. The graph shows that the fresh-water fish contains only one enzyme exhibiting thiaminase activity. These results are in full agreement with those reported by earlier workers. While working with a carp, which is a fresh-water fish, Woolley *et al.*[3] reported optimum activity at

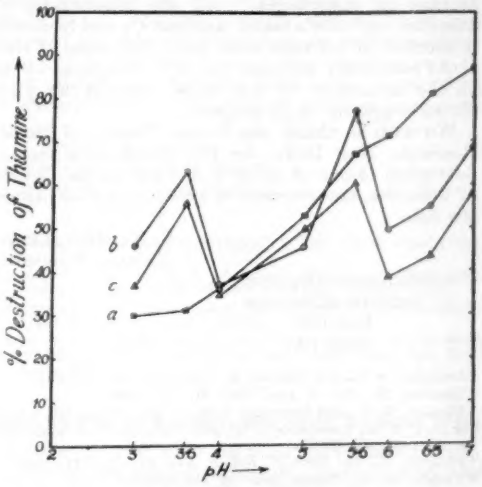

Fig. 1. Effect of *p*H on thiaminase from fish: (*a*) *Barbus sarana*, fresh-water fish, (*b*) *Mugil* sp., brackish-water fish, (*c*) *Coilia dussumieri*, salt-water fish

*p*H 8·0, Sealock *et al.*[4] at *p*H 9·1 and Bhagwat *et al.*[5] at *p*H 6·0.

The curves for brackish-water fish and salt-water fish closely resemble each other, but vary remarkably from that obtained for the fresh-water fish. In the case of brackish- and salt-water fish, there are three different hydrogen ion concentrations (namely, *p*H 3·6, 5·6 and 7·0) at which the enzyme exhibits optimum activity. This confirms our previous observation[1]. From the above results it appears that there are at least two thiaminases having optimum activity: (i) in the neutral or slightly alkaline range; and (ii) in the acid range. This difference may be due to the composition of the water and other environmental factors.

Extracts from all the three different varieties of fish were dialysed, and it was observed that the enzymes having optimum activity at *p*H 3·6, 5·6 and 7·0 from brackish- and salt-water fish and the enzyme from the fresh-water variety lost the greater part of their activity. The activity, however, could be restored in all cases by the addition of boiled original extract, thus confirming the presence of a coenzyme in all cases, as reported in a review article by Yudkin[6].

The effect of the addition of certain metallic salts, namely, sulphates of copper, zinc, manganese, magnesium, iron, cobalt and nickel (*M*/100 concentration) to the dialysed extract was studied, and it was found that only manganese and cobalt salts could restore the activity of the enzyme exhibiting optimum activity at *p*H 3·6 and 5·6. None of these salts could, however, restore the activity of the enzyme exhibiting optimum activity at *p*H 7·0 from brackish- and salt-water fish, or that of the enzyme from fresh-water fish. This confirms our previous observation that the enzyme having optimum activity at *p*H 7·0 is altogether different from those having optimum activity at *p*H 3·6 and 5·6.

Fractional precipitation with organic solvents such as acetone, alcohol and dioxan failed to separate the three thiaminases; all three could be precipitated at 50 per cent saturation of ammonium sulphate. Adsorption-elution procedures were tried with a

number of adsorbents. All the thiaminases are adsorbed on fuller's earth, alumina Cγ and bentonite. A number of solvents were tried, but none of them could selectively separate the three enzymes. Work on the separation of the three enzymes by paper chromatography is in progress.

We wish to thank the Indian Council of Medical Research, New Delhi, for the award of a research fellowship to one of us (S. T. D.) and to the Director of Fisheries, Government of Bombay, for identifying the fish.

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Free Amino-Acids in the Yolk during the Development of the Chick

The progressive appearance of free amino-acids in the yolk during the development of the chick have been examined by paper chromatography, and we have observed that the density of the spots, from comparable aliquots, of yolks from fertilized hen's eggs increased from the fourth to the tenth day and decreased after this to the twelfth. To test these observations by an additional approach, similar samples were chromatographed on 'Dowex'[1] and the results are reported here.

Whole yolks of fertilized hen's eggs at the stages of embryonic development indicated were precipitated with a solution containing 2 ml. of 1·0 *N* hydrochloric acid per 100 ml. acetone. For each yolk approximately 150 ml. of acetone was added. The water in the yolk made this aqueous acetone approximately 80 per cent acetone. The extracts were evaporated at 25° C. under moving air. The dried residues were dissolved in known amounts of citrate buffer, *p*H 3·4, and, after centrifugation, aliquots representing approximately 10 gm. of yolk were chromatographed on 100 cm. and 15 cm. 'Dowex' columns[1]. Proline was introduced into some extracts in order to relate other chromatographic positions with the increased absorption at 420 mμ that characterized the reaction product when this amino-acid is treated with ninhydrin. The paper chromatography followed the procedure of Levy and Chung[2]. Acids were identified by relating the chromatographic positions of known acids with those of the unknown acids, and by comparing the effluent acids from aliquots of the extracts examined on 'Dowex' columns with the distribution of the amino-acids on paper from the corresponding sample.

Table 1. Free Amino-Acids in the Yolk of the Fertilized Hen's Egg at Several Stages of Embryonic Growth

Amino-acid	Days of incubation 3	6	9	12
	(μ*M* per aliquot*)			
Threonine	—	0·65	3·9	0·91
Serine	0·35	1·9	5·0	1·8
Glutamic	0·22	0·46	3·2	0·79
Proline	—	1·6	6·8	0·40
Glycine	—	0·41	4·4	—
Alanine	—	0·61	3·7	0·71
Cystine	—	0·56	0·99	0·75
Valine	—	0·51	1·3	1·1
*iso*Leucine	1·1	1·9	2·7	0·92
Leucine	2·2	2·0	4·0	1·0
Tyrosine phenylalanine	2·3	1·3	5·3	1·3
Lysine†	0·67	0·69	2	1·0
Arginine†	—	—	1·5	—
Methionine	0·10	0·20	0·20	—

* Each aliquot represents the free amino-acids from 10 gm. yolk.
† Released from 15-cm. 'Dowex' columns.

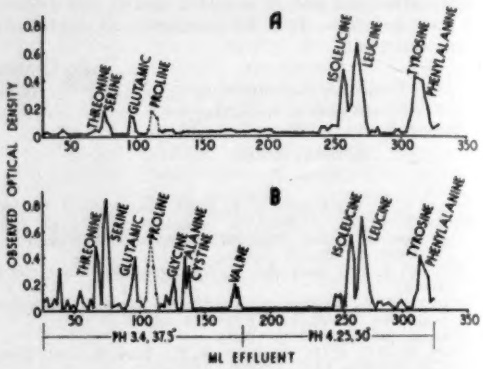

Fig. 1. Chromatographic separation of the amino-acids quantitatively released from 100-cm. columns of 'Dowex 50' with buffered solvents. *A* and *B* represent samples of yolks from fertilized eggs incubated three and six days respectively. Dotted lines indicate measurements at 420 mμ. 60 per cent of the peak shown for proline in *B* was due to introduced proline (see text). Methionine (unlabelled) is on left of *iso*leucine. The temperature on these columns was at all times less than 75°, and therefore the emergence of tyrosine and phenylalanine together in the effluent is not a limitation of the published procedure (ref. 1)

Typical chromatograms are shown in Fig. 1. The free amino-acids (Table 1) increase to the ninth day, but decrease on the twelfth day. Presumably these changes are related to the progressive proteolysis of the yolks, an observation not previously described for the yolk[3] of the hen's egg, although it is known to contain three proteinases[4]. The absence of fixed relative quantities of amino-acids characterizing the intervals sampled is interesting. Similar observations were made on the basis of the density of the spots on paper chromatograms of samples of yolks from the fourth to the twelfth day. It is unlikely that the relative concentration of amino-acids appearing on the ninth, as contrasted with the twelfth, day are a function of proteolysis alone. Such changes are doubtless related to the demands in protein synthesis during the development of the chick.

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Waste of Carbon and of Energy in Nitrogen Excretion

It is commonly accepted that, in nitrogen excretion, urea—and more especially uric acid—are wasteful to the organism in that they involve the loss of carbon and, moreover, chemical energy (see, for example, Needham[1]). Compared with ammonia, these substances are regarded as inefficient and as only resorted to under the exigencies of water conservation. Table 1 summarizes data from the literature, from which it is seen that, per nitrogen atom, the order of carbon waste (column *c*) is :

ammonia < urea < uric acid (or 0 ; 0·5 ; 1·25).

But the amounts involved are scarcely significant ; for example, for a man to excrete 30 gm. urea plus 0·7 gm. uric acid per day (Starling[2]) means the loss of 6·25 gm. carbon, which can be made up by the intake of 15·6 gm. glucose or equivalent. Similar calculations may be made for other non-ammonotelic animals.

In considering the energy factor, Needham quotes heat of combustion values for these three nitrogenous compounds in kcal./mole (column *d*), where the waste is in the order :

ammonia < urea < uric acid (or 1 : 1·69 : 5·11) ;

but it will be more pertinent to examine the figures for kcal./mole/nitrogen atom (column *e*), in which case the heat of combustion values appear in the order :

urea < ammonia < uric acid (or 1 : 1·18 : 1·51).

However, it may be considered that the free energy of formation gives a truer indication of the energy relationships to the organism, and the order for these values is :

ammonia < urea < uric acid (or 1 : 7·73 : 14·52),

when calculated as kcal./mole (column *f*), and

ammonia < uric acid < urea (or 1 : 3·63 : 3·87),

when calculated as kcal./mole/nitrogen atom (column *g*).

Table 1

a	*b*	*c*	*d**	*e*	*f*†	*g*
	Empirical formula	Ratio C/N	$-\Delta H$ Heat of combustion (kcal./mole)	Heat of combustion (kcal./mole/ N atom)	$-\Delta G$ Free energy of formation (kcal./mole)	Free energy of formation (kcal./mole/ N atom)
Ammonia	NH_3	—	90	90	6·3	6·3
Urea	CON_2H_4	0·5	152	76	48·7	24·4
Uric acid	$C_5O_3N_4H_4$	1·25	460	115	91·46	22·87

* The figures in column *d* are given in Needham as cal./mole, but they should obviously read kcal./mole.

† The figures in column *f* refer to the aqueous state for ammonia (Partington, ref. 3) and for urea (Parks and Huffman, ref. 4) ; the figure for uric acid is for the solid state (Partington), and in view of the low solubility in water the figure for the aqueous state will be slightly reduced.

Thus it may be concluded that : (i) ammonia is the most advantageous from the point of view of economy in carbon and in energy (except slightly in $-\Delta H$ calculated per nitrogen atom) ; (ii) urea wastes less carbon than does uric acid, but the amount is unlikely to be significant in either case ; (iii) urea is approximately as wasteful as uric acid, and both are somewhat more wasteful than ammonia, in terms of $-\Delta G$ calculated per nitrogen atom, but the waste of chemical energy is not nearly as great as is generally implied.

It is suggested that the question of which nitrogenous end-product is resorted to may still be considered as depending on the abundance of the water supply of the organism, but that urea and uric acid excretion are not as disadvantageous as is sometimes expressed in the literature. Any disadvantage in terms of carbon and energy waste is far outweighed by the advantages conferred by ureo- or urico-tely.

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Stimulation of Certain Bacteria by Raw Milk

Although raw milk contains bacteriostatic substances, certain concentrations of it actually stimulate some micro-organisms such as *Streptococcus agalactiae* and *Str. lactis*[1]. Since the bacteriostatic properties appear fairly constant[2], variations in stimulatory properties may account for the observations of seasonal variation in the growth-rate of micro-organisms in milk[3].

Using cows infected in one or more quarters of the udder with mastitis, it has been found that milk from infected quarters is more stimulatory to *Str. agalactiae* than milk from non-infected quarters of the same udder.

Colostrum taken just before cows calved had a very high stimulatory effect, whereas just after calving the effect was much less. This is interesting, as it is known that cows are more susceptible to mastitis during the dry period.

A range of amino-acids and growth-factors was examined to discover whether any had stimulatory properties like those of raw milk. Only certain sulphur compounds gave positive results. Sodium sulphide and thioglycollic acid were stimulatory at concentrations down to 10^{-3} *M* ; cystine and cysteine were still effective at 10^{-5} *M*. Sodium sulphate was without effect.

It is suggested, therefore, that the concentration of certain sulphur compounds normally present in traces in milk affects markedly the rate of growth of some micro-organisms. The same factor may also control the susceptibility of cows to mastitis.

This work, which was carried out during the tenure of a British Council Scholarship at the National Institute for Research in Dairying, was part of an investigation on the inhibitory and stimulatory properties of milk.

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Separation of Pigment Cells of Cacao

The purple pigment in the cotyledons of unfermented Forastero cacao is distributed in separate cells which are readily seen in cut sections. These separate cells can also be seen in sections from the Pale Criollo cacaos, though they are not coloured purple.

During the fermentation process, the contents of these cells dissolve, and diffuse throughout the cotyledons and into the testa of the bean. Some constituents of the substance of the cells undergo oxidative and other changes, and some of the material is lost into the 'sweatings' which drain from the fermenting beans.

When the freshly harvested beans are dried rapidly, there is no diffusion of the substance of the pigment cells, which can be seen apparently intact in sections of the cotyledons of beans dried in this way. These dried pigment cells have a higher density than the other cells of the tissue, and a separation of them has been effected as follows.

The dried beans are freed from testa and radicle, the cotyledons crushed to a suitable degree—a household coffee mill with the finest setting has been found suitable—and the ground mass suspended in petrol. The fat is dissolved, and of the mixture of insoluble suspended matter, the protein and starch are almost completely removed by sedimentation and decantation. The heavier mixture of free pigment cells and coarse tissue, mainly cellulose, is then sifted through a 240-mesh sieve suspended in petrol. The coarse, less dense, tissue is held on the sieve and is rejected; the free pigment cells pass through the sieve. Further careful sedimentation and decantation, preferably from a shallow dish, give a final product of separated pigment cells with about 5 per cent of adherent extraneous matter which is not removed by further washing with petrol.

The whole amount of the pigment cells in the cotyledons is not recovered in this way; some cells are too firmly attached to the lighter tissue and do not pass through the fine sieve. When carefully dried beans are used, about one-half of the total can be recovered as separated cells.

These dried pigment cells are dark purple, almost black, in the case of West African Amelonado cacao, somewhat lighter and redder purple in the case of most West Indian and South American cacaos, and a light puce colour in the case of East Indian and other 'white' Criollo cacaos.

The pigment cells are rather larger than the other cells of the dried cotyledons, the maximum lengths being about 50 μ and 35–40 μ respectively.

It has been found that the whole of the purin substances, and probably the whole of the polyphenolic substances, in the cotyledons are concentrated in these pigment cells. They dissolve almost completely in water, giving a solution of *p*H 6·5–6·7, the same as that recorded for an aqueous extract of the fresh whole cotyledons[1].

The proportion of pigment cells in the total tissue of the cotyledons has been determined from a comparison of theobromine contents, and found to vary from 11 to 13 per cent by weight in the air-dry cotyledons. This compares well with the figure of about 10 per cent by count quoted by Knapp[2].

This separation of the polyphenolic and purin constituents from the other components of the bean provides a new and better approach to the study of these constituents, particularly the polyphenols. Solutions can be prepared which are free from extractives from other components of the bean, and are less labile than solutions from extracts of the whole cotyledon.

This is being applied, and analyses obtained giving comparisons between cacaos from different sources.

This work was carried out in the laboratories of Messrs. Rowntree and Co., Ltd., York, and is communicated by permission of the directors.

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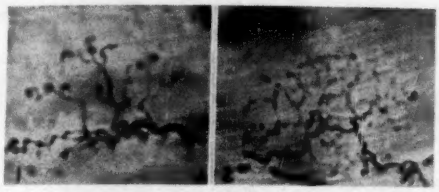
Intra-arterial Injection of Methylene Blue for Staining Nerve Endings in Striated Muscles

The difficulty of staining nerve endings with methylene blue is well known. I have found that intra-arterial injection of methylene blue in an anæsthetized animal consistently stained the nerve endings of striated muscles with greater uniformity than was possible by intravenous injection or the local infiltration of methylene blue. The method used is as follows.

Under ether anæsthesia, a convenient artery supplying the muscles the nerve endings of which are to be stained (for example, the femoral artery for staining the endings in the muscles of the hind-legs) is exposed and dissected free. The staining fluid consists of 0·25 per cent zinc-free methylene blue in a solution of 0·8 per cent sodium chloride, 0·2 per cent glucose, 0·02 per cent magnesium bromide, buffered to a *p*H of 6 with phosphate buffer[1], with 1 mgm. of hyaluronidase[2] added to 20 ml. of the solution immediately before use. The fluid is warmed to the body temperature and slowly injected into the exposed artery by means of a syringe and a needle of suitable size until the skin over the injected part turns deep blue in colour. The amount required for this depends, of course, on the dimension of the area to be injected, hence preliminary trials are usually necessary to find the right dose. In adult rats and chickens, injections of about 4 and 40 ml. respectively into the femoral artery stained the nerve endings in the hind-legs. The tendency at the beginning is to inject too little, but an overdose results in the undesirable staining of the blood cell and muscle nuclei or in the death of the animal.

After injection, arterial bleeding from the withdrawal of the needle is stopped by clamping the artery with artery forceps, and the animal is kept alive under anæsthesia for 10 min. before killing it by bleeding. The muscles are removed, the large muscles are sliced to about 3 mm. in thickness, and they are suspended on hooks in an oxygen chamber kept damp by a piece of wet cotton-wool. After about half an hour the 'blued' muscles are examined under the microscope and pieces that contain stained nerves and endings are selected for fixation overnight in chilled 8 per cent ammonium molybdate solution. Serial frozen sections are cut, rapidly dehydrated in chilled *n*-butyl alcohol, cleared in xylene and mounted in canada balsam.

This method had been successfully used in staining the nerve endings of the leg muscles of rat, rabbit,



Two types of nerve endings in M. extensor et adductor digitorum of the second and third wing digits of the chicken, stained by the injection of methylene blue into the brachial artery. (× 300)

frog and chicken (Figs. 1 and 2). The endings in the intercostal and diaphragmatic muscles of rats have also been demonstrated by retrograde injection through the carotid artery into the aorta.

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Conductivities of Polyelectrolyte Solutions at High Frequencies

THE electrical conductivity of aqueous solutions of electrolytes increases with increasing frequency of alternating current. For simple electrolytes such as potassium chloride, this increase in conductivity does not become apparent until the frequency is of the order of 10 Mc./s.

The explanation of this phenomenon is given by the Debye–Hückel theory of electrolytes, that when the time of relaxation of the ionic atmosphere is greater than the period of the alternating current used, then an increase in conductivity of the solution will occur. It was found, when experiments were being carried out on aqueous solutions of the polyelectrolyte sodium polymethacrylate, that an increase in conductivity occurred at a much lower frequency than with the corresponding concentration of potassium chloride solution.

If we consider an assembly of uncoiled long-chain polyions in an alternating electric field, the effect of the latter will be to cause displacements of the polyions or segments of polyions within their cylindrical ionic atmospheres. The rate of recovery from displacements in the direction of the axis will be relatively slow, since the ionic atmosphere will retain its cylindrical symmetry, and the restoring force will therefore be small.

As regards displacements resolved at right angles to the axis of the polyion, one would expect the time of relaxation to be similar to that of a small spherical ion. The summation of the various displacements should clearly result in the appearance of a frequency effect at a lower frequency than is observed with small spherical ions.

The apparatus for proving that the effect occurred consisted of a variable-frequency oscillator giving a constant voltage output. The current was passed through the conductivity cell, which was in series with a variable resistance, and a high-frequency milliammeter. At a particular frequency, if the conductivity decreased, then the series resistance could be varied until the same ampere reading on the high-frequency milliammeter was noted. The adjusted reading on the variable resistance gave an indication of whether or not an increase in conductivity had occurred.

The readings from the instrument for the sodium polymethacrylate solutions were compared with standard potassium chloride solution, keeping all the conditions in both experiments identical, so that any stray capacitance effects were the same in both sets of solutions. This showed that the conductivity of sodium polymethacrylate solutions began to increase at a much lower frequency, that is, at about 0·1 Mc./s.

We wish to thank Mr. J. Rawcliffe and the Electrical Engineering Department of the College of Technology, Manchester, for technical advice while carrying out this work.

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Thermal Conductivity Measurements on Inert Media using Internal Calorimetry

INTERNAL calorimetry[1], developed for the measurement of blood flow, is basically a method for thermal conductivity determination. It uses a fine-gauge heated thermocouple embedded in the organ or medium under examination. In simple media a steady heating current applied to the filament raises the temperature recorded by the thermocouple. Temperature equilibration is rapid. Heat exchanges[2] are governed by Carslaw's equation[3]: $I^2R = 4\pi.r.\theta.k$, where k is the thermal conductivity of the medium, I the heating current, R the resistance of the heater, r the radius of a thermodynamically equivalent sphere and θ the temperature increment. Thus the relation between I^2 and θ is linear when k is constant; $4\pi r/R$ is a constant for any given recorder and constitutes its standardization factor (F), the experimental determination of which has been fully described elsewhere[4].

The accuracy of the method was tested using various media. All determinations were carried out in a temperature-controlled room (20° ± 1° C.), with the medium in a water-bath at 20° C. In each case the relation between I^2 and θ was plotted from 0° to 3° C. at intervals of 0·2 deg. Knowing F, the thermal conductivity, k, was readily determined. The accuracy with solids and semi-solids was good, but was greatly reduced in liquids. The following values represent an average of three separate determinations, and are compared with figures quoted in the "International Critical Tables".

Substance	k (observed)	k (I.C.T.)
'Vaseline' (at 0° C.)	$4{\cdot}55 \times 10^{-4}$	$4{\cdot}40 \times 10^{-4}$
Paraffin wax (m.p. 50° C.)	$6{\cdot}45 \times 10^{-4}$	$6{\cdot}0 \times 10^{-4}$
Liquid paraffin	$3{\cdot}66 \times 10^{-4}$	$3{\cdot}11$–$4{\cdot}54 \times 10^{-4}$
Glycerol	$6{\cdot}72 \times 10^{-4}$	$6{\cdot}58$–$7{\cdot}41 \times 10^{-4}$
Water	$13{\cdot}6 \times 10^{-4}$	$12{\cdot}86$–$14{\cdot}23 \times 10^{-4}$

To accelerate equilibration it was usual to overheat the filament, then cool to the required temperature increment. In most media, equilibrium, once reached, was thereafter maintained indefinitely.

In 'Vaseline', however, it was found that about 20 sec. after cooling to the appropriate temperature a slow upward temperature drift began. Experiments were therefore carried out in which a steady current (such as would theoretically raise the temperature of the heater by 1 deg.) was suddenly applied to the recorder[5]. In 5 per cent gelatin gel, liquid paraffin, paraffin wax and glycerol no further temperature drift occurred after the calculated 1 deg. increment had taken place, but in 'Vaseline' the upward drift continued during the whole period of recording. In one experiment the temperature rose steadily during 30 min. to a value of 1·78 deg. higher than the theoretical equilibrium.

Read and Lloyd[6] showed that a marked drop in thermal conductivity in tri-nitro-toluene occurred at or near the melting point. It seemed possible that a similar alteration in the thermal conductivity of some of the hydrocarbon components melting at 20–21° C. might explain the present findings. 'Vaseline' was stored in a refrigerator for a week, when its temperature was 4° C.; this temperature was probably lower than the melting point of any of the components. With the 'Vaseline' in a freezing mixture a steady heating current was applied as before. No temperature drift now occurred; thermal equilibrium was rapidly reached and maintained throughout the recording period.

These experiments emphasize the suitability of internal calorimetry for measuring thermal conductivity in non-fluid media. They also give fresh evidence suggestive of changes in thermal conductivity in a hydrocarbon mixture at about the melting point.

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Energy Requirements for Ion Transport in Steady-State Systems

Several investigators[1–3] have attempted to calculate the energy required to maintain steady-state exchanges of ions between animal tissues and their environments. Thus, Krebs, Eggleston and Terner[1] concluded that about 2·5 per cent of the respiratory energy was required for potassium exchange in brain cortex slices at 40° C., and Bernstein[2] calculated that the steady-state exchanges of sodium and potassium in red blood cells at 37° C. may require up to one-third of the free energy from glycolysis. These calculations[1,2] were based on the assumptions that there was 100 per cent efficiency in the utilization of metabolic energy for ion transport, that the losses and gains of the same ion were independent, and that the movements of different ions were also independent of one another. These assumptions are not necessarily valid.

The value obtained for the free energy change in the net transport of 1 mole of ion from one electrochemical potential to another represents the minimum energy requirement in a biological system. If some of the potentially available energy is not used in doing useful work, then the actual energy requirement will be more than that calculated from thermodynamics. In addition, the exchanges of one ion for another of the same kind in a steady-state system may not require any expenditure of energy since no net transport occurs[3–5]. This is the case in a Donnan system and an ion-exchange resin in equilibrium with an aqueous salt solution. Harris[6] has, in fact, shown that part of the to-and-fro movements of sodium and potassium in red blood cells takes place without a supply of energy. The migrations of different ions may also be linked[7]. The figures given above, obtained by the application of kinetic data on steady-state exchanges to thermodynamic data for net transport, are therefore maximum values of minimum ones and may have no significance.

This method of calculation has been applied to results[8] on the exchange of sodium and potassium in guinea pig kidney cortex slices in steady states *in vitro*. It leads to apparently reasonable conclusions for respiring tissue (see also Krebs and co-workers[1]) but to impossible conclusions for tissue in anaerobic conditions. Thus, respiring slices at 37° C. would need about 6 per cent of the potentially available metabolic energy for the steady-state exchanges of sodium and potassium. Anaerobically the $Q^{N}_{CO_2}$ (μl./mgm. dry wt./hr.) was + 2·3 at 37° C. and less than + 0·1 at 0° C. The exchange-rates (μmoles/mgm. dry wt./hr.) between the intra- and extra-cellular fluids at the two temperatures were 3·6 and 3·1 for sodium and 0·9 and 0·5 for potassium respectively. The potassium concentration in the tissue was about five times that in the medium, and a similar ratio for sodium was about 0·6 at both temperatures. Even on the assumption that the whole of the carbon dioxide evolved was associated with reactions yielding the same energy as those in lactic acid production from glucose (cf. Bernstein[2]) these results mean that, on the basis of this method of calculation, the energy requirements for steady-state exchanges of sodium and potassium at 37° C. and 0° C. would be 190 per cent and 2,500 per cent respectively of that which is available. It is of interest that the rate of exchange of potassium between 'Zeo-Karb 225' (10–30 mesh) and 0·01 *N* potassium chloride in equilibrium with it was found to be 10–25 times greater than the rates in kidney slices, though, of course, no energy was supplied.

These results show that it is not possible to calculate energy requirements for steady-state exchanges of ions from kinetic and thermodynamic data without information on the mechanisms responsible for the exchange.

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Vibrations as a Cause of Disintegration in Liquid Sheets

During photographic investigations into the disintegration of liquids by means of single-fluid pressure-atomizers, it was established that the liquid first forms a thin sheet which disintegrates well away from the mouth of the nozzle. The modes of disintegration of these sheets are influenced by the properties of the liquid, the nozzle, and the surrounding atmosphere. In certain circumstances, holes are formed in the sheet which are observed to expand rapidly as they travel away from the nozzle. This process is illustrated by a high-speed photograph of a sheet of mercury as it leaves a single-hole fan-spray nozzle (Fig. 1).

It has been established that holes in the sheet can be caused by the presence of non-wettable particles in the liquid or by certain turbulence characteristics in the nozzle, as expressed by an appropriate Reynolds's number. Investigations into the latter cause reveal a phenomenon which may give a clue to the flow mechanism in all types of nozzles traversed by compressible or incompressible fluids. Vibrations which give rise to the noise phenomenon in gaseous jets are thought to be set up by the flow of the gases through the nozzle. These periodic disturbances have for some time been the subject of observation, experiment and mathematical analysis. With liquid jets there is much evidence of turbulent, unsteady flow behind the nozzle being a primary cause of disintegration, but no experimental confirmation of periodic vibrations in liquid jets has yet been forthcoming.

Observations on sheets of liquid such as the above show random centres of disturbance which, as they travel away from the nozzle mouth, eventually break the film and result in holes. Fig. 2 shows a section of a sheet of mercury illuminated obliquely to disclose the disturbances on its surface.

A mathematical analysis of these random disturbances shows that their origin is inside the nozzle just behind the mouth, and that the frequency of the observed ripples in the sheet is of the order of 10 kc./s. Systematic work may reveal the cause of these disturbances and link them to possible vibrational phenomena inside the nozzle.

Fig. 1

Fig. 2

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High-Voltage Arcs in Argon–Nitrogen Mixtures

It has been known for some time that unusual discharges can be maintained in the gaseous filling (argon–nitrogen, 99·5 per cent, 0·5 per cent at about 600 mm. pressure) of commercial incandescent lamps[1]. Recent studies of high-voltage arcs (1,000–2,000 V., 0–50 m.amp., 60 c./s.) struck in the gaseous filling between the filament support leads of such lamps have been reported[2]. When running the arc at low currents (0–5 m.amp.), it appeared as a yellow-brown 'flame-like' glow, which had a distinct life-time of luminosity of the order of 1 sec. after the power had been switched off. As previously reported, the spectrum of this glow, photographed on Kodak *I–N* plates between 3500 and 9000 A., showed only the following bands:

N_2 First positive system: (1,0), (2,1), (2,0), (3,1), (3,2) [(4,2), (5,3), faint]

N_2 Second positive system: (0,1), (0,2), (0,3), (0,4), (1,3), (1,4), (1,5)

This communication directs attention to probable excitation mechanisms involving vibrational levels of the $X^1\Sigma_g^+$ state of N_2, which now seem superior to those discussed previously[2] in the explanation of this unusually low vibrational excitation of the $C^3\Pi_u$ and $B^3\Pi_g$ states of N_2 exhibited in this source.

The combined phenomena of unusually low vibrational excitation of the $C^3\Pi_u$ and $B^3\Pi_g$ states, and

of an afterglow life-time of about 1 sec., strongly suggest that energy exchanges involving atoms and molecules in metastable states are taking place in the source. The available metastable states are: nitrogen, $a'^1\Pi_g^+$, $a'^1\Sigma_u^-$, w, $A^3\Sigma_u^+$, $X^1\Sigma_g^+$ $(v > 0)$; argon, ^3P. The vibrational levels of the ground-state $X^1\Sigma_g^+$ of N_2, populated by emission of the Lyman–Birge–Hopfield and Birge–Hopfield systems, are metastable towards a radiative transition of electric dipole type to lower vibrational levels of the same state, as such transitions are 'forbidden' by a selection rule, N_2 being homonuclear. Thus nitrogen molecules in vibrationally excited levels of $X^1\Sigma_g^+$ have unusually long lives which will be terminated only by such processes as collision deactivation at the wall.

In the thermionically supported discharge plasma, some direct excitation of all atomic and molecular levels will be expected, but excitation of the singlet states of N_2 may be expected to predominate[3]. Subsequent radiation of the Birge–Hopfield and Lyman–Birge–Hopfield levels will, as explained above, cause levels of $X^1\Sigma_g^+$ to become populated up to $v = 26$ [4]. Recently computed values of vibrational transition probabilities of the Lyman–Birge–Hopfield system[5] shows that levels $v = 2,3,4,5$ of the $X^1\Sigma_g^+$ state will be populated preferentially in this way.

While the collision phenomenon (1)

$$N_2(a^1\Pi_g^+, a'^1\Sigma_u^-, w) + A(^1S_0) + \text{slow electron} \rightarrow N_2(B^3\Pi_g, v \text{ small}) + A(^1S_0) + \text{slow electron} \quad (1)$$

cannot be disregarded as a possible way in which the $B^3\Pi_g$ levels become populated, it seems reasonable to suppose that the reactions (2)

$$N_2(X^1\Sigma_g^+, v \sim 26) + A(^1S_0) + \text{slow electron} \rightarrow N_2(A^3\Sigma_u^+, v = 0,1) + A(^1S_0) + \text{slow electron}, \quad (2)$$

$$N_2(A^3\Sigma_u^+, v = 0,1) + N_2(X^1\Sigma_g^+, v \sim 2\text{–}5) + A(^1S_0) \rightarrow N_2(B^3\Pi_g, v \sim 0\text{–}3) + N_2(X^1\Sigma_g^+, v \sim 0) + A(^1S_0),$$

would also be probable in view of the close energy equalities exhibited throughout, and because of the long lives and expected abundances of the reactants on the left-hand sides of (2). Subsequent radiation of the (0,0), (1,0), (2,1), (2,0), (3,2), (3,1) bands of the first positive system is then predicted from recent computations of vibrational transition probabilities of this system[6].

The preferential population of the $v = 0,1$ levels of the $C^3\Pi_u$ state may be similarly explained in terms of mechanism (3):

$$N_2(X^1\Sigma_g^+, v \sim 20) + N_2(A^3\Sigma_u^+, v = 0,1) + A(^1S_0) \rightarrow N_2(C^3\Pi_u, v = 0,1) + N_2(X^1\Sigma_g^+, v = 2,3) + A(^1S_0), \quad (3)$$

$$\text{or} \rightarrow 2N_2(X^1\Sigma_g^+, v \text{ small}) + A(^3P_0). \quad (3)$$

The second alternative would occur if sufficient energy were available to excite levels of $C^3\Pi_u$ higher than $v = 1$. The metastable argon atoms taking part in the collision would then be preferentially excited. The observed bands of the second positive system (0,1), (0,2), (0,3), (0,4), (1,3), (1,4), (1,5) are those which would be predicted as most probably arising from the $v = 0,1$ levels of the $C^3\Pi_u$ state from recent values of the vibrational transition probabilities of this system[6].

Experimental work on these discharges is continuing.

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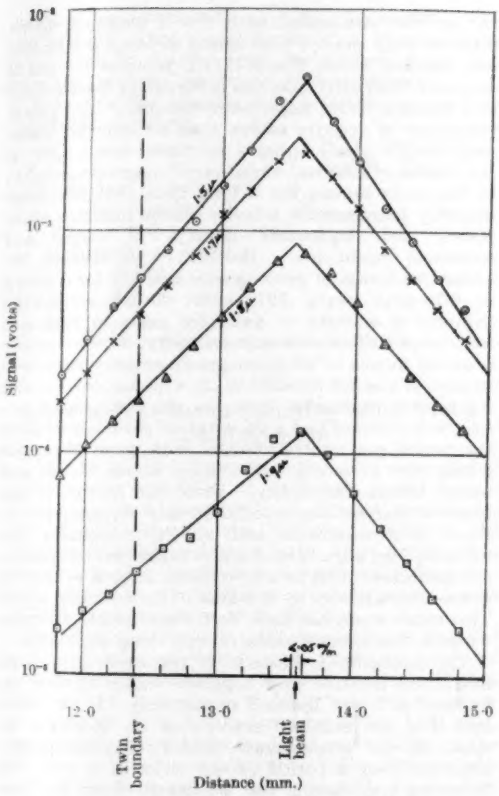
Transmission of Electrons and Holes Across a Twin Boundary in Germanium

The recently developed technique[1] of investigating the diffusion of minority carriers in an ambipolar semiconductor has been applied to the study of a twin boundary in germanium. Twinning about a (111) plane readily occurs in crystals having the diamond structure, such as germanium and silicon. A single crystal of *n*-type germanium, containing one twin boundary, was pulled from the melt by the Czochralski technique. The material used was of reasonably high purity, approximately 5 ohm-cm. resistivity at room temperature. A slice approximately 0·5 mm. thick was cut from this in such a manner that the twinning plane was perpendicular to the surface, which was then ground in the usual manner and etched in *C.P.*4 [2]. The specimen was irradiated with a narrow beam (0·05 mm. wide) of chopped infra-red light, having a wave-length comparable with the width of the forbidden energy gap, 0·72 eV. A probe close to the illuminated spot picks up an electrical signal which corresponds to the change in the Fermi-level or the floating potential under the probe. This change in the potential is proportional to the local density of minority carriers excited across the energy gap by the absorption of the radiation. The drop in signal strength observed as the light spot is gradually moved away from the probe is due to the decay in the number of these carriers. In a single crystal, such decay is caused mainly by recombination of the excess carriers at trapping centres, and a logarithmic plot of signal strength versus distance should give a straight line, the slope of which determines the diffusion distance, closely related to carrier mobility and life-time.

If the texture is not perfect, a discontinuity in signal strength would be expected wherever the electrons meet some major defect in the structure, which would result in the setting up of a potential barrier. The measurements on the specimen described, which was apparently perfect apart from the twin boundary, are plotted in the accompanying figure; they show no discontinuity, the lines being in fact quite straight and of identical slope on either side of the probe, which was located 1·1 mm. away from the boundary. Apparently, electrons passed across this boundary just as freely as they moved in the crystal where they originated.



The diffusion distances derived from these measurements are given below, together with the corresponding life-times, calculated on the assumption of 43 cm.^{2} sec.$^{-1}$ for the diffusion coefficient of holes. The somewhat lower value for 1·5 μ is presumably due to the increased absorption of the radiation near the surface layer and the correspondingly higher rate of recombination there.

Wave-length (μ)	1·5	1·7	1·8	1·9
Diffusion distance (mm.)	0·54	0·63	0·65	0·66
Life-time (μsec.)	68	92	98	102

As a further check on the transmission of holes across a twin boundary, transistor action was investigated on another similar crystal with an emitter point on one side of the twin boundary and a collector on the other. The two points were spaced about 0·2 mm. from either side of the boundary. Distinct transistor action was observed as readily as on any similar piece of single-crystal material.

It would therefore appear that, in contradistinction to grain boundaries, twin boundaries will not impede the transmission of free electrons or holes to any marked degree. This is not surprising, as the transmission from one twin to the other takes place across a single atomic layer; also, the energy involved in twinning is quite negligible compared with the main lattice energy. Electrons and holes can obviously bridge such a narrow region by the wave mechanical tunnel effect without any marked resistance.

It is suggested that similar techniques might, with advantage, be applied to the study of various faults in the structure of solids, as, for example, to the boundary region between two grains which have been made to grow with certain specified orientations.

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Fatigue Strength of Pure Tin at Room Temperature

The fatigue strengths of many tin alloys at both room and elevated temperatures have been reported[1], but I have found no figure for pure tin in the literature. Experiments have therefore been made to determine the fatigue strength of the pure metal in the cast condition. The measurements were made on a Wöhler type machine with four-point loading, using a relatively thick specimen with a short gauge-length.

Tests were made up to 10^8 cycles of stress and these showed no evidence of a true fatigue limit. The fatigue strengths at 10^7 and 10^8 cycles of stress are 0·19 and 0·17 ton per square inch respectively.

It is of interest that the fractures produced by fatigue were wholly intercrystalline. After testing, the grain boundaries were revealed on the polished surface of the specimen, indicating that intergranular movement had taken place during the test. In addition, a general roughening of some grains indicated that transcrystalline deformation occurred at the same time, either on sub-boundaries or on slip planes.

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Graphite Lubrication in Grey Cast Iron

During work with the Lunn apparatus[1] on dry friction between a sliding tungsten carbide ball and a grey cast iron test-piece, two different types of tracks were obtained. The first type of track had a black appearance when examined with the naked eye or in the microscope, and a continuous film of deformed graphite covered the surface of the track. The L value of this film was high, which indicated good electric conductivity of the film. The second type of track had a bright, metallic appearance, and on examination with the microscope very small amounts of deformed graphite were observed. In this case, the L value was low, which indicated the build-up of an insulating film—even if the specific pressure is of the magnitude of 10,000–12,000 lb./sq. in.

The two types of tracks could be produced on the same test-piece, depending on the conditions under which the experiment was carried out. If conditions did not allow water vapour to be adsorbed to the cast iron surface, the first type of track was obtained. Adsorption of water vapour always resulted in a change to the second type of track.

These observations made on grey cast iron are in agreement with the experiments of Savage[2] on the lubricating effects of pure graphite.

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Very Long Sequences of Geomagnetic Activity and its Annual Variation

It is well known that moderate geomagnetic storms tend to recur after 27 days. Such storms are not related to sunspots, are almost always of gradual commencement type and are well marked only during two or three years immediately preceding the sunspot minima. A large number of such sequences, consisting of seven or eight storms, have been recorded; a few much longer sequences have been mentioned by Bartels[1]. The longest sequence of which we are aware in the literature consisted of seventeen recurrences between December 9, 1929, and March 13, 1931.

We have studied the recurrence tendency of geomagnetic activity for the three-year period 1950–53. A plot of three-day running means of the international magnetic character figures *C* for this period indicates that sequences of magnetic activity last much longer than has been thought hitherto. Our study further indicates that, after exhibiting well-marked storm-like characteristics for about five to six recurrences, the activity diminishes to such proportions that it can no longer be identified with a storm. Very often this may be regarded as the end of a sequence. We find, however, that the activity, after remaining low for a few recurrences, again becomes appreciable and the continuity of the sequence is maintained.

During the three-year period under consideration two long sequences have been identified. These sequences will be called *A* and *B* respectively. In addition, there are a few short sequences corresponding to two or more 27-day rotations and a few individual peaks of considerable activity, the latter mostly associated with sudden commencement type of storms. The major part of the activity, however, is covered by the *A* and *B* sequences.

The *A* sequence which commenced with the moderate storm of July 11–12, 1950, has continued to date; the latest storm of this sequence as recorded at Kodaikanal commenced on September 19, 1953. The *B* sequence appears to have begun on November 21, 1951, and has also continued to date, the latest storm in the sequence having started on September 3, 1953. The total number of recurrences of the *A* sequence so far is 40, and that of the *B* sequence 21. Most of the time the magnetic activity for both the sequences has been pronounced after 27 days, but in a few cases the period between individual days of highest activity was 26 or 28, and only in a very few cases 25 or 29. The mean period between recurrences for each one of the sequences is found to be 27·05 days.

The activity on individual days when it was maximum during the recurrences has been plotted for the two sequences using the actual *C*-figures for the days concerned. The curves show a regular periodicity; the activity associated with the *A* sequence shows maxima only once a year about September–October and minima about March–April, whereas for the *B* sequence the yearly maxima occur about March–April and minima about September–October. The yearly maximum of activity rather than six-monthly maximum (equinoctial) appears to throw some light on the causes of seasonal variation of magnetic activity. It has been known for a long time that the mean monthly geomagnetic activity shows maxima about March and September—months of vernal and autumnal equinoxes. Bartels[1], who studied the annual variation of geomagnetic activity for a period of fifty-nine years, 1872–1930, found equinoctial maxima of activity to exist for years of high and medium as well as low sunspot activity. However, since monthly means of all geomagnetic activity were used by him, it was not possible to say whether, corresponding to each individual *M*-region, the variation of geomagnetic activity had a six-monthly period or whether the period was twelve months, with some *M*-regions giving rise to maximum activity about March and others about September. From his harmonic dial method, Bartels concluded that only the semi-annual wave of geomagnetic activity was physically significant. The sequences *A* and *B* which, in our opinion, are associated with two *M*-regions, show a behaviour quite contradictory to the idea of semi-annual wave. This result could not have been conclusively obtained without the identification of very long sequences.

The heliographic latitude of the earth attains its maximum positive and negative values of 7·2° on September 7 and March 5 respectively. If we postulate that the intrinsic activity of an *M*-region responsible for geomagnetic activity remains nearly constant over a period of the order of a year, the following conclusions can be drawn from the geometry of the situation. (*a*) If an *M*-region is located at heliographic latitude greater than 7·2° north or south, there will be a single maximum of geomagnetic activity centred around September 7 or March 5, depending upon whether the *M*-region is in the northern or the southern solar hemisphere respectively, with the minimum occurring on the other date. (*b*) If the heliographic latitude of the *M*-region is less than 7·2° north or south, there will be two maxima of activity situated more or less symmetrically about September 7 or March 5, depending upon the hemisphere (north or south) in which the *M*-region is located. The displacement from these dates will depend upon the latitude of the *M*-region. (*c*) If the *M*-region is located on the solar equator, there will be two maxima, about December 6 and June 6.

From our study of the recurrent storms during the period 1950–53 we may conclude that:

(1) There were two principal long-lived *M*-regions separated in longitude by about 130°. These were responsible for two separate long series of magnetic storms.

(2) A single yearly maximum for each of the series indicates that these *M*-regions were located at heliographic latitudes greater than 7·2°. The mean period of recurrent geomagnetic activity of 27·05 days indicates their position at 7·5° heliographic latitude if judged from synodic rotation period of sunspots and 16° if considered from that of prominences.

(3) The characteristic annual variation of geomagnetic activity, which was mainly associated with solar *M*-regions during the three-year period considered here, is found to be due to the approach of the earth's projection on the solar disk towards the

zones of maximum solar activity. Incidentally, this explanation of the annual variation is in accord with that given by Cortie[2] from his studies of the geomagnetic activity associated with sunspots.

Details of the investigation reported here will be published elsewhere.

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[1] Bartels, J., *Terr. Mag.*, **37**, 1 (1932).
[2] Cortie, A. L., *Mon. Not. Roy. Astro. Soc.*, **73**, 52 (1912).

Size of Fragments resulting from Tidal Disintegration

The size of tidal fragments of a body composed of rock or ice, according to Jeffreys[1], would exceed 200 km. Since primary tidal stresses are tensile, they would elongate the disrupted body in the direction toward the other body, thus producing a long axis in this direction and tearing the disrupted body into disks the thickness of which might be, as Jeffreys suggests, more than 200 km.

The effect of secondary tidal stresses is not included in Jeffreys's computations and, therefore, his conclusions are questionable for large bodies. Within Roche's limit, the gravity holding the body together is neutralized only in the direction of the long axis, but is unaffected at right angles thereto. That is, the pressure on the materials varies from zero at both ends of the long axis to approximately its original value midway between. In the central disks, the secondary stresses due to the weight of the material must be considered in addition to the tidal tension tearing the body apart. Other secondary stresses due to change in direction of primary tidal stresses are minor, and are not discussed.

For example, consider that a body of the size and density of the earth is being disrupted by a tidal encounter, and that its surface rocks have a density of 3 gm./cm.^{3} with an ultimate crushing strength of 2,000 kgm./cm.^{2}. In the central disks the ultimate crushing strength of the rock would be reached at a depth of 6·7 km. below the surface. Below this level the rocks would fail by compression and shear, the materials of the disks would bulge into the widening rifts, and spalls and other fragments would fall into these rifts. Meanwhile, fragments less than a kilometre in size from above the 6·7-km. level would be broken off by tension, for the tensile strength of rock is less than 0·1 its compressive strength. Wherever the compression stresses exceed the ultimate strength of the rock, much of the rock would be crushed into small pieces, of which many would be as small as sand. Pieces falling into the rifts would be broken by impact.

Thus it seems possible that the combination of primary tidal tension and secondary stresses of compression, shear and tension would be competent to produce fragments much smaller than the 200-km. minimum computed by Jeffreys.

In the case of tidal disruption of smaller bodies, the size of fragments would vary approximately inversely as their acceleration of gravity; but even if the disrupted body were only a few hundred kilometres in diameter, it would still be possible that secondary stresses would produce many small fragments.

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[1] *Mon. Not. Roy. Astro. Soc.*, **107**, 260 (1947).

Processes controlling Zygophore Formation and Zygotropism in *Mucor mucedo* Brefeld

Aspects of the process of conjugation in Mucoraceae have recently been discussed by Raper[1], Goodwin[2], Hawker[3] and Catcheside[4]. In view of current interest in sexual processes in the Thallophytes the following incomplete results are presented.

Burgeff[5] believed that zygophore formation in *Mucor mucedo* was sometimes induced by an air-borne volatile substance or substances; he and Köhler[6] also produced evidence for a water-soluble hormone which acted similarly after diffusing through the substrate. I have grown strains of *M. mucedo* from Baarn (showing no spontaneous zygophore formation) in a closed-ring system through which air was constantly recirculated while slowly exchanging with the outside atmosphere. Colonies, (+) and (−) in an alternating linear series on small separate blocks of agar, did not form zygophores when separated by 3-mm. air gaps; when they were separated only by sheets of permeable 'Celloidin' (which remained unpenetrated by hyphæ) zygophores arose in the contact zones. There does not appear to be any strong evidence for air-borne induction of zygophore formation. Several workers have obtained evidence for the existence of diffusing hormones in the substrate, but no active extract or metabolite fluid has been isolated.

Two methods have given inconclusive but promising results. In the first, liquid decanted from mixed (+) and (−) mycelia growing submerged in aerated 2 per cent malt extract solution, filtered, and concentrated by partial freezing and removal of ice, was tested by transferring to antibiotic assay cups placed about 3 mm. from the growing edge of (+) and (−) colonies. Occasionally in repeated tests local production of zygophores was observed in the (+) but not in the (−) colony. Malt solution alone treated as above had no effect. Recently, using a modification of Raper's cascade technique, distinct zygophore formation (with no signs of copulation) was observed when 2 per cent malt extract solution having previously passed through (+) and then (−) mycelia reached a second (+) culture. This unfortunately gives no clear indication of the sequence of hormone production, but it is hoped that current work will provide an unequivocal answer on this point.

The next stage in the conjugation process, the zygotropic response, was studied using small blocks of agar cut transversely from the copulation zone between (+) and (−) colonies newly grown into contact in Petri dishes. There was thus a tuft of unmixed (+) zygophores at one end of the block, a mixed tangle with copulation in the middle, and (−) zygophores at the other end. Successive series of these blocks were then arranged by hand or micromanipulator so that zygophores of one type were brought near those of either the same or alternatively the opposite mating type, pointing in various directions, and at various distances. Repeated observations confirmed

the mutual positive response between (+) and (−) zygophores. Further, a mutual aversion between zygophores of the same mating type was discovered; that is, (+) zygophores are repelled by (+), and (−) by (−). The attraction has been detected over a distance of 2 mm., the repulsion over 1 mm. Neither effect was shown when the zygophores on one side of the gap were replaced by vegetative mycelium of either mating type bearing sporangiophores but no zygophores.

Vandendries and Brodie (see Buller[7], and Langeron[8]) claimed that the repulsion, over distances of up to 3·5 mm., which they observed between certain haplonts of *Lenzites betulina* was transmitted through thin air-tight barriers of glass, mica, celluloid and silver, and must be due not to a chemical stimulus but to radiations. I was unaware, until recently informed by Dr. J. H. Burnett, that this claim was later withdrawn by Vandendries[9] in a little-known paper. In my experiments, when thin barriers (2–50 mgm./cm.²) of fused quartz, glass, mica or aluminium foil were erected between paired tufts of zygophores prepared as above, no attraction or repulsion was observed, nor was it when normal diffusion between zygophores was interrupted by a current of moist air from a micro-jet. Using mica or aluminium foil with a fine perforation as a barrier, attraction was manifested, (+) and (−) zygophores respectively curving from opposite sides and growing towards the pore even when the arrangement was such that no straight path existed between any zygophore on one side through the hole to one on the other side. These results indicate that zygotropism in *M. mucedo* is a form of chemotropism and not, as suggested by Köhler, a response to any electromagnetic radiation. It seems necessary to postulate two volatile substances, one evolved by (+) zygophores, stimulating elongation growth in (+) zygophores and retarding it in (−) zygophores, the other evolved by (−), stimulating (−) and retarding (+). A directional response could occur, since the frequency with which diffusing molecules of the active substance impinge on the near face of the zygophore is greater than on the side away from the source: estimates of the difference suggest values of the order of 0·1–0·5 per cent. This is of the same order as the estimated minimum difference in light-energy absorption required for phototrophic curvature of *Phycomyces* sporangiophores under unequal bilateral illumination[10], so a zygotropic curvature from such a minute difference is quite conceivable.

A more extensive account of these and other observations, with appropriate acknowledgments, is being submitted for publication in the *Journal of Experimental Botany*.

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Nematode-destroying Fungi in Agricultural Soils

In view of the serious losses to crops caused by eelworms, and the possibility that their destruction by predacious fungi may be of potential value as a means of control, some knowledge of the natural occurrence of these fungi in arable soil is desirable. The results set out below are those of a survey carried out on forty-nine samples of soil from various parts of England. The samples were taken from arable land, much of which was infested with potato root eelworm or cereal root eelworm, and from glasshouses in Warwickshire in which tomatoes were the principal crop, and in many of which the potato root eelworm was causing damage.

For examination of the samples, a little soil was scattered on the bottoms of sterile Petri dishes, and maize-meal agar, cooled to about 40° C., was poured into the plates, the soil being slightly mixed with the agar by gentle tilting. The medium was approximately neutral in reaction, no adjustment of *p*H having been made. The plates were incubated at room temperature, and periodically examined for predacious fungi. In order to keep down the growth of moulds, a very weak infusion of maize-meal was used in making up the medium. Predacious fungi usually began to appear in about a fortnight after inoculation, feeding on the free-living eelworms that wandered out on to and into the agar. Each batch of plates was kept under observation for a minimum period of three months.

From the forty-nine samples that were examined, eighty-two records of nematode-attacking fungi were made, a list of which is given below; the numeral following the name of the fungus represents the number of samples in which it was found.

Arthrobotrys dactyloides Drechsler	4
A. oligospora Fres.	21
A. robusta Duddington	3
Arthrobotrys spp.	2
Dactylaria candida (Nees) Sacc.	2
D. psychrophila Drechsler	1
Dactylella bembicodes Drechsler	1
D. cionopaga Drechsler	1
D. lobata Duddington	1
Dactylaria or *Dactylella* spp.	2
Trichothecium cystosporium Duddington	3
Acrostalagmus obovatus Drechsler	5
**Acrostalagmus* sp. 282, n.sp.	1
**Haptoglossa heterospora* Drechsler	1
Harposporium anguillulae Lohde	6
H. lilliputanum Dixon	1
Meria coniospora Drechsler	1
**Nematoctonus leiosporus* Drechsler	2
**N. pachysporus* Drechsler	1
Mycelium 186	18
Unidentified hyphomycetes	5
Total number of records	82

* First British record

The fungus referred to as 'Mycelium 186' is very common in soil. It is clearly a member of the Zoopagaceae, having non-septate hyphæ that capture nematodes by simple adhesion, no specialized organs of capture being formed. No reproductive bodies of any kind have been observed, nor has the fungus ever appeared in any other habitat save soil. A full description of this fungus will be published elsewhere. *Acrostalagmus* 282 is a hitherto undescribed species with clavate spores; it is here placed for convenience in *Acrostalagmus* Corda (*sensu* Drechsler), but may ultimately have to be described as the type of a new genus, owing to the unsatisfactory taxonomic status of *Acrostalagmus*. The interesting fungus *Haptoglossa heterospora*, probably best placed in the Lagenidiales, has already been found in soil in Denmark by Shepherd (*in litt.*).

A consideration of the list brings out one or two interesting points. The commonest fungus is *Arthrobotrys oligospora* (21 records), which is not surprising in view of its widespread distribution in many kinds of habitat[1]. Its great preponderance over all other species except 'Mycelium 186' is, however, surprising. Easily the second commonest is 'Mycelium 186' (18 records); as this fungus has been recorded only from soil, it would seem likely that it is a specialized soil species, and it is possible that its constant failure to produce spores when grown on agar media may be correlated with this. How it reproduces in its natural habitat is not known, but among other factors the disruption of soil by earthworms might perhaps be considered. Like *Arthrobotrys oligospora*, it outnumbers other fungi in the list to a surprising extent. *Arthrobotrys dactyloides*, capturing eelworms by means of constricting rings, appears to be more frequent in soil than elsewhere. It has been obtained in Great Britain from compost by Dixon (personal communication), but apart from its occurrence in soil it does not appear to be a common British species. It has also been observed in Danish soil by Shepherd (*in litt.*). *Trichothecium cystosporium* is fairly prominent, and this species has also been isolated from soil on a previous occasion[2]. The other species in the list call for no particular comment, though the frequencies of the ubiquitous *Harposporium anguillulae* and *Acrostalagmus obovatus* may be noted. The preponderance of hyphomycetes capturing nematodes by means of adhesive networks is also interesting.

Attempts to correlate the presence or absence of particular fungi with soil factors such as *p*H, etc., yielded no results; but it is clear that many more soil samples will have to be examined before any such correlations, if present, can be expected to become apparent. Quantitative information on the distribution of predacious fungi in soil is also badly needed; this work is now in hand, and it is hoped to make it the subject of a future communication.

I should like to express my thanks to Mr. F. G. W. Jones, School of Agriculture, Cambridge; to Mr. H. C. F. Newton, Miss C. M. G. Duthoit and Mr. H. J. Ward, of the National Agricultural Advisory Service, West Midland Province; and to Mr. M. Brook, of Boots Pure Drug Co., for their help in providing many of the soil samples on which this preliminary survey has been based. The work has been made possible by a grant from the Agricultural Research Council, to which my thanks are also due.

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Demonstration of a Diffusible Fruiting Factor in Myxobacteria

RUNYON[1] gave a demonstration of a diffusible factor inducing the formation of fruiting bodies in Myxamoebae. Attempts to demonstrate a similar factor in *Chondromyces* by Bonner[2] are inconclusive because they resulted in mechanical disturbance of the swarm and of the surface of the medium, which are sufficient, in my experience, to stimulate the formation of fruiting bodies (cf. also Stanier[3]).

A very striking demonstration of such a factor in myxobacteria was obtained by placing squares, about 2 cm. × 2 cm. × 4 mm., of non-nutrient agar over fruiting bodies of one strain of *Chondrococcus exiguus* and two of *Myxococcus xanthus* grown on a killed suspension of *Aerobacter aerogenes* in non-nutrient agar. The upper surface of these agar squares was inoculated with suspensions of vegetative cells, grown on one-tenth strength routine nutrient agar, which supports their growth but does not permit formation of fruiting bodies. Great care was taken to avoid mechanical disturbance of the agar surface; and as controls similar inoculated squares were placed on uninoculated *A. aerogenes* suspension plates, and some squares covering fruiting bodies were left uninoculated.

After three days incubation at 28° C., profuse formation of fruiting bodies occurred in the vegetative cells placed over fruiting bodies of the same species, but not in the controls, or in those vegetative cells of *M. xanthus* which were placed over fruiting bodies of *Ch. exiguus* or vice versa. The two strains of *M. xanthus* were mutually stimulatory.

Fruiting bodies did not form immediately over those below, but were most profuse at the edges of the inoculum, that is, at the greatest concentration of vegetative cells. This appears to indicate that the factor is rapidly diffusible. Further, increased formation of fruiting bodies in the areas covered by the agar was found to occur both with inoculated and uninoculated squares, and was apparently due to the mere presence of the agar.

It has been suggested by Quehl[4] that compatibility, as indicated by the coalescence of vegetative swarms in close proximity, might be employed as a means of definition of species in myxobacteria. However, it is my experience that otherwise identical swarms may fail to coalesce, and it may be that the mutual stimulus of the formation of fruiting bodies could be employed for species or type differentiation.

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Delay of Chromosome Rejoining in *Vicia faba* induced by Irradiation

I HAVE shown[1] that fractionation of X-ray dosage administered to seeds of *Vicia faba* soaked in water causes no decrease in the number of two-hit chromosomal aberrations. However, with additional soaking in the protective agent, 2,3-dimercapto-propanol (BAL), previous to irradiation, a decrease is achieved on dosage fractionation. In order to further the understanding of this phenomenon, the following dosage-intensity experiments were performed. A constant dosage of 600 r. of 250 kVp. X-rays was administered in 3-min., 1-hr., 2-hr. and 3-hr. periods. The numbers of ring and dicentric chromosomes in 300 metaphase plates of the *X*-1 root-tip division were scored at each intensity.

As can be seen from Fig. 1, in those seeds soaked in water alone, there is no significant difference in the number of aberrations produced by the highest

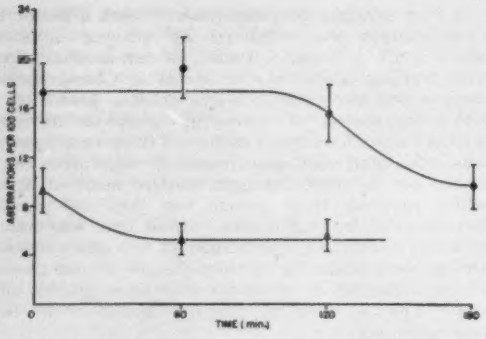

Fig. 1. Effect of intensity on chromosome aberrations. Upper curve, seeds soaked in water; lower curve, seeds soaked in 2,3-dimercapto-propanol

three intensities. Only when the dose is administered over a greater period of time than 2 hr. is there a decrease in the number of aberrations. This is easily explained if one assumes that no rejoining of broken chromosome ends occur within 2 hr. of the onset of radiation. However, if the seeds are pre-soaked for 1 hr. in a solution of 2×10^{-3} *M* 2,3-dimercapto-propanol, there is a significant decrease in the number of two-hit aberrations as the intensity is decreased; evidently the 2-hr. lag period, during which little or no rejoining normally occurs, has been decreased. This effect of 2,3-dimercapto-propanol, a powerful antioxidant, strengthens the hypothesis that the major effect of anoxia is on the restitution of broken chromosomes[1,2] rather than on the initial breakage[3].

That the rings and dicentrics scored are authentic two-hit aberrations may be ascertained from the dosage curve in Fig. 2, which shows that the numbers of these aberrations increase as the square of the dose. This is contrary to previously published dosage curves[4] on two-hit chromosome aberrations in the seed of *Vicia faba*. This discrepancy is probably due to the fact that a large proportion of the anaphase bridges scored by others[4] as two-hit aberrations are in reality the result of one-hit isochromatids.

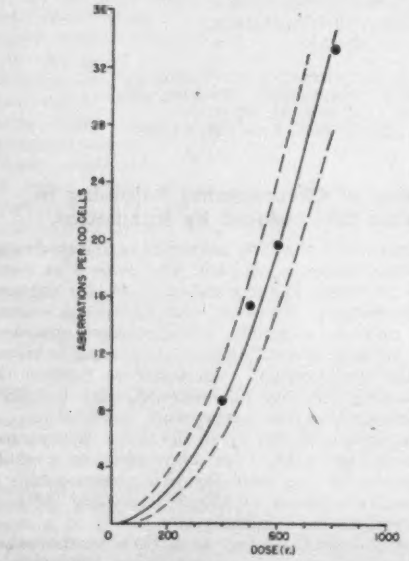

Fig. 2. Dosage curve of two-hit chromosome aberrations. Intensity, 200 r./min. Dotted lines enclose 95 per cent confidence limits

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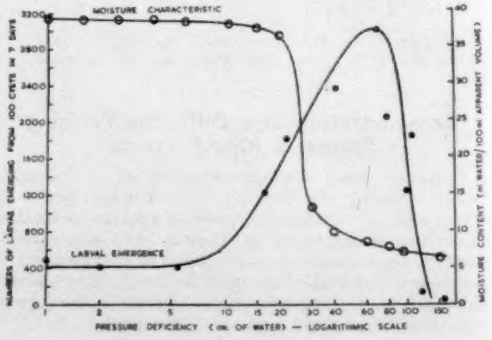
Hydrostatic Pressure-Deficiency and the Emergence of Larvæ from Cysts of the Beet Eelworm

Larvæ of the beet eelworm (*Heterodera schachtii* Schmidt) are essentially water-inhabiting creatures, and their behaviour in the soil is governed by the properties of the soil water. The results of an investigation into the relationship between hydrostatic pressure-deficiency in an artificial soil composed of sand and water, and the number of larvæ emerging from the eelworm cysts, are summarized here.

One hundred cysts, mixed in 9 gm. of sand of particle-size 60–160 μ, were placed in each of a series of sintered glass funnels. Suction was then applied to the sand and water in each funnel to give a range of pressure-deficiencies. The apparatus was kept in a constant-temperature room at 24° C. (± 0·5° C.). The relationship between the logarithm of the pressure-deficiency (*pF*) and the numbers of larvæ emerging is shown in Fig. 1.

A comparison of the curve for the moisture characteristic (that is, the curve of moisture content plotted against the logarithm of pressure-deficiency) with the curve for larval emergence and the logarithm of pressure-deficiency shows that a relatively low emergence occurs with 1–10 cm. pressure-deficiency when the sand is saturated. Maximum emergence corresponds to the pressure-deficiency at which the last pore space is emptied of water.

Other experiments have shown that larval emergence is dependent on oxygen concentration; at low oxygen concentrations (1–2 mgm. of oxygen per litre)



emergence is almost nil. It is suggested that the relatively low emergence occurring during 1–10 cm. pressure-deficiency is due to low oxygen concentration in the water around the cysts when the sand is saturated and the pore spaces are filled with water. An increase in emergence occurs after 10 cm. pressure-deficiency, when air appears in the pore spaces, resulting in increased oxygenation of the water film. Emergence rises to a maximum at 70 cm. pressure-deficiency, after which there is a decline. Two possible explanations of this decline are suggested. Egg hatch may be inhibited by the extraction of water from the cysts, and larval emergence may be impeded by the surface forces of the water film.

The effects of oxygen concentration, temperature, saturation deficiency, size of soil particles and different soil types on larval emergence are also being investigated.

I am indebted to the Sugar Beet Research and Education Committee for providing facilities for carrying out this investigation.

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Hardness of Arthropod Mouthparts

It is well known that many insects are able to bore through packing materials, including metal foils, used for wrapping foodstuffs and other commodities. During an attempt to develop a physical barrier that would be resistant to penetration by insects, the hardness of the mouthparts of a number of insect pests was determined.

Richards[1] considers the question of the hardness of arthropod cuticle, but it appears that no determinations have been made. In view of this, representatives of several insect orders and of other classes of arthropods were included in these tests.

Fresh materials were used in each case and the mouthparts, generally the mandibles, were removed and cemented to needles. Scratch tests were carried out on the minerals in Moh's scale of mineral hardness (see Lange[2]) which would appear to be the appropriate standard.

Determinations were made on species of the following genera:

Insecta
  Coleoptera: *Tenebrioides*, *Rhizopertha*, *Stegobium*
  Lepidoptera: *Pteroloscura*
  Isoptera: *Mastotermes*
  Orthoptera: *Calolampra*
Crustacea
  Decapoda: *Cherax*
Myriapoda
  Chilopoda: *Scolopendra*
Arachnida
  Scorpionidea: *Cercophonius*
  Araneida: *Isopeda*

In each case the hardness was found to be approximately 3, the specimen of calcite being scratched with difficulty. Minerals softer than 3 were readily marked. In view of the function of mouthparts, this may represent the highest value to which arthropod cuticle can be hardened.

It is of interest to consider the role taken by calcification of the cuticle which occurs notably in the Crustacea. Many authors have examined the calcium salts involved, and it appears that calcium carbonate in the form of calcite is the usual deposit. Whatever properties calcification may modify, it is clear from the present results that it will neither harden nor soften the cuticle.

From the above evidence there would appear to be no physical difficulty in insects boring through foils made from such common metals as lead, tin, copper, zinc and silver, providing that these have not been work-hardened.

I am indebted to Mr. A. Musgrave, of the Australian Museum, for identification of the Arachnida.

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Effect of Refrigeration of the Pupæ of *Microbracon brevicornis* Wesm. on the Pigmentation of the Adult

During the course of mass breeding of *Microbracon brevicornis* in the parasite laboratory of the Entomology Division of this Institute for the purpose of exporting them to the United States of America for the control of pink boll worm in the cotton belt of that country, it was necessary to maintain a stock of pupæ of the parasite in cold storage at a temperature of 10 ± 3° C. It was observed that the adults emerging from the chilled pupæ which had been in cold storage from 10 to 75 days showed dark pigmentation ranging from dark grey to jet black, as against the distinctly brown individuals obtained from unchilled pupæ.

The possible effect of humidity on the production of melanic forms was eliminated by subjecting the pupæ to low (10 ± 3° C.) and high (25° C.) temperatures at different humidities. Irrespective of the humidity, the parasites that underwent metamorphosis under low temperature always showed darker pigmentation. Similarly, the effect of light on the pigmentation of the adults also showed that while dark forms emerged from chilled pupæ, whether kept in darkness or in light, all adults that were obtained from pupæ at higher temperatures under both conditions were brown individuals. It was thus concluded that low temperature alone was responsible for the abnormal pigmentation of adults obtained from the chilled pupæ.

Kaestner[1] observed that when females of *Habrobracon* are exposed to extremes of heat or cold, the parasites became dark and the effect was transmitted apparently through the plasma to the next generation. However, in the present case it has been observed that the dark forms when bred at a temperature of 25° C. and 70 per cent humidity gave rise to normal brown individuals. Evidently in this case the progeny has failed to inherit the acquired character of their parents, and we are therefore unable to confirm Kaestner's observations. Genies, Schlottke and also Kuhn[2] have shown that, in the case of *Microbracon habetor*, at low temperatures the black pigments become dominant, whereas at higher temperatures the pigmentation is more reduced until finally entirely yellowish forms are produced. In the present case, even when the parasites were bred at 35° and 40° C., they did not exhibit any loss of pigment-

ation. Genies and others have not connected low temperature with depressed metabolism in insects, which appears to be one of the probable causes for dark pigmentation.

The conclusion from these experiments is that pigmentation in this case is perhaps a physiological phenomenon caused by the inability of cells to dispose of the breakdown products of metabolism in chilled pupæ at a low temperature; these products tend to increase and accumulate as the period of refrigeration is extended. This explanation supports the hypothesis put forward by Cordier[3] that "the production of melanin is sometimes regarded as a mechanism for disposing of toxic phenols arising as breakdown products in metabolism".

Extending these findings to field-conditions, it will now be possible to explain the occurrence of seasonal forms of *M. brevicornis*. A source of confusion is the great variation in colour to which *M. brevicornis* is liable; it is evident that the difference in colour is almost valueless in defining species. The parasite over-winters in the pupal stage and therefore the adults emerging from the over-wintering pupæ are dark in colour compared with the brown forms that emerge during the spring. This was confirmed by the specimens collected from cotton fields in northern India where, during the months of January and February, the field-temperature is very low. Hence it is possible that early workers in India, though they might have reared *M. brevicornis* from pink boll worm (*Platyedra gossypiella* Saunders), took it for granted that the parasite was *M. lefroyi* D. and G., and never recorded *M. brevicornis* as a potential parasite of pink boll worm.

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Nov. 17.

[1] Kaestner, M., *Arch. Entw. Mech.*, **124**, 1 (1931).
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Culture of Insect Tissues

In recent years, in fact since the culture of vertebrate tissues became an accepted laboratory technique, insect physiologists have attempted to produce cultures of insect tissues. So far, they have not succeeded. All that has been achieved with insects is the maintenance of organs in a living state[1], sometimes with the continuation of metamorphic changes[2], or a limited growth of tissues still organically connected with the living body of the insect[3]. The literature also contains reports of insect-tissue culture which can be assigned to one of two classes: either growth has genuinely taken place during an experiment of extremely short duration[4], or else what was probably a mere cell migration, such as I have found with *Rhodnius prolixus*, was recorded as growth[5]. The criterion of a tissue culture which is to compare with vertebrate tissue culture would seem to be the possibility of maintaining it by means of sub-cultures, over an extended period of time, and it is in this sense that previous efforts may be said to have failed.

Apart from the work of Luscher[2], which in any event was not intended as a true *in vitro* cell culture, no attempts at tissue culture have been carried out on insects of the order Hemiptera–Heteroptera, of which *Rhodnius prolixus*, a useful and convenient laboratory insect, is a representative. It seemed to me that *R. prolixus* would be a very suitable insect for such experiments, since so much is already known about it. It has been found, for example, that the epidermis of *R. prolixus* will grow when implanted into the body cavity of another individual, whereas the other tissues degenerate[6]. The epidermis of this insect will also grow to a certain extent along glass tubes inserted into the cut ends of limbs[5]. The processes of wound repair in the living *R. prolixus* are well known[7], and have been found to involve the proliferation of the epidermal nuclei.

In the experiments to be described here, fourth and fifth instar nymphs of *R. prolixus*, which had been fed four to seven days previously, were used. They were surface sterilized for five minutes in 0·1 per cent aqueous mercuric chloride, washed in three changes of sterile water, and then put into a sterile Petri dish lined with filter paper, where they remained until dry. Using a sterile technique, hanging drops of the insect's hæmolymph were made, in which small snips of the abdominal cuticle and epidermis were suspended. Care was needed in order not to puncture the blood-laden stomach, and drops which were visibly contaminated with the stomach contents were discarded. Altogether, forty-eight sterile drops were prepared, and the proportion of losses due to bacterial infection was very small when mercuric chloride sterilization was used. Lysol (25 per cent) and methylated spirits were also tried as sterilizing agents, but had a deleterious effect on the insects, as shown by the failure of controls, sterilized but not dissected, to recover. It was found that bacterial infection was much more severe in drops made after the use of these latter sterilizing agents, and this suggests some ability of undamaged cells to cope with invading micro-organisms.

In a typical hanging drop, visible changes could be seen to occur, but unfortunately they can only be regarded as degenerative in nature. After the first twenty-four hours, a mass of vacuoles and chromatic granules flowed out from the edge of the cuticle, while the rest of the epidermis contracted towards the centre of the cuticular fragment. Hæmolymph cells were numerous in the drops at first, but disappeared later. In three of the drops, there were many amœboid hæmolymph cells, which coalesced into compact groups, and remained for the duration of the experiment. Their nuclei stained apparently normally at the conclusion of the period of incubation. After 10–14 days incubation at 30° C., that is, a few days after visible changes had ceased, the preparations were fixed and stained. Many nuclei could be seen, but rather weakly stained, and no mitoses were visible.

A few trials were made with other parts of the anatomy of *R. prolixus*, such as heart, testis, muscle and fragments of unfed first instar bugs; with bacteriological broth instead of hæmolymph as a medium; and with tissues of the cockroach *Blatta orientalis*. No success attended any of these variations.

There are two obvious developments of the methods here employed which occur to me and may be mentioned. The first is to replace glass surfaces by

mica, or cover them with a film of wax, and the second is, by analogy with vertebrate tissue culture, to enrich the culture medium with an extract of *R. prolixus* embryos. These developments have not been possible at present, and the brief account given here is for the benefit of those who may wish to follow this line. It is important to emphasize that, up to now, there is no indication whatever that insect tissues will form cultures of the sort familiar with vertebrate material.

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Nov. 19.

[1] Ragab, H. A., *Trans. Roy. Soc. Trop. Med. Hyg.*, **43**, 225 (1949).
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Occurrence of *Puccinia polysora* Underwood in the Indian Ocean Area

The maize rust fungus *Puccinia polysora* was first described in 1897 by Underwood in Alabama on *Tripsacum*, a plant allied to maize; it was later also found on *Erianthus*, a species of grass related to the sugar-cane. In 1941, Cummins detected the fungus for the first time on maize in the United States, but a careful review of herbarium material collected earlier from different parts of the Continent and deposited as the common maize rust, *P. sorghi* Schw., brought out that many of the specimens had indeed been attacked by *P. polysora*.

The new rust, which does not apparently cause severe injury to maize in the New World, was until recently unknown in the Old; but in 1949 a severe outbreak of the disease was observed in Sierra Leone in West Africa. The following year, serious epidemics broke out in Liberia, Ivory Coast, Gold Coast, Dahomey, Togoland and Nigeria, resulting in food shortage among the native tribes. By the end of 1952, the disease had spread to Tanganyika, Uganda, Nyasaland and Kenya, and had reached the east coast of Africa.

In March 1953, the rust was detected in violent epidemic form at various widely separated places in Mauritius, and in May last I identified the disease in the neighbouring French island of Réunion, which I was visiting on a short mission.

In a letter dated September 29 last, the Director of the Phytopathological Laboratory of the Pasteur Institute of Tananarive informed me that he had newly identified the disease in certain districts along the east coast of Madagascar, the attack in one of the regions having been observed as from March 1953; but it was stated that there were no records of recent maize importations in Madagascar.

In Mauritius, legislation was promulgated in February 1951 prohibiting the importation of maize from the then affected West African areas and territories bordering them. Maize meal is, however, regularly introduced from Kenya by the military authorities for feeding the Askari soldiers stationed in the island since the Second World War; and washings from contaminated meal could account for initial foci of infection in a new area. There does not, however, seem to be very strong reasons for considering that the disease was introduced into Mauritius in the Kenya consignments, unless it already existed in that country some time prior to its detection in 1952.

Réunion is about four hundred miles off the east coast of Madagascar and Mauritius one hundred miles farther eastward. Together with Rodrigues, four hundred miles still farther east of Mauritius, these two islands constitute the Mascarene Archipelago; but there is as yet no record of the presence of *P. polysora* in Rodrigues.

Both Mauritius and Réunion are linked with Madagascar and Africa by regular air services, while Mauritius is one of the fuelling points for Qantas aeroplanes on their route between South Africa and Australia via the Cocos Islands. The presence of *P. polysora* in Mauritius, which is the most easterly point it has yet reached, thus constitutes a menace both to Asia and Australia.

It has also been found in the United States and Canada that the spores of the cereal rusts can be carried in a viable condition by air currents to altitudes more than 15,000 ft. and to distances of several hundreds of miles from their point of origin. This means of spore distribution is now considered by some as possibly accounting for the present rapid spread of *P. polysora* in Africa. Its simultaneous discovery in 1953, for the first time, in Madagascar, Mauritius and Réunion would appear to support the hypothesis of spread by means of air currents.

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Geographical Distribution of Mating Types in *Gibberella cyanogena* (Desm.) Sacc.

Gibberella cyanogena, the ascomycetous stage of *Fusarium sambucinum* Fuckel f. 6 Wr., has been previously reported[1] to be bisexual (hermaphroditic) and self-sterile. In other words, single-ascospore and monoconidial cultures of this fungus belong to one or other of two mating types, designated m.t.^{A} and m.t.^{a}, both of which may function as male and female but are self-sterile. For the production of fertile perithecia under laboratory conditions it is necessary to bring together cultures of the two mating types and maintain them under the appropriate environmental conditions.

The examination, by mating tests, of mass cultures of the Fusarium stage of this fungus that were

Geographical area	Habitat	State of fungus	Mating type
Canada			
British Columbia	potato tubers	Fusarium	m.t.^{a}
Alberta	,,	,,	,,
Saskatchewan	,,	,,	,,
Manitoba	,,	,,	m.t.^{A} and m.t.^{a} separately
New Brunswick	,,	,,	m.t.^{a}
Prince Edward Island	,,	,,	m.t.^{A} and m.t.^{a} separately
England	*Polygonum sieboldi* DeVr.	Gibberella	m.t.^{A} and m.t.^{a}
New Zealand	wheat	Fusarium	m.t.^{a}
Scotland	*Viola* sp.	,,	,,
Tasmania	hops	,,	m.t.^{A}

isolated from decaying potato tubers in Canada as well as from additional habitats in other geographical areas has revealed that the two mating types occur separately in Nature. In no instance were the two mating types found occurring together in the same mass isolate of the Fusarium stage. Their occurrence together in Nature has so far been determined only from a single collection of the Gibberella stage. In the accompanying table is shown the geographical distribution, and habitats, of the two mating types in *G. cyanogena* so far determined by me.

The ability of the two mating types to become established separately in Nature would appear to explain why *Gibberella cyanogena* has so far not been encountered in Canada, where *Fusarium sambucinum* f. 6 is widely distributed.

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Nov. 19.

[1] Gordon, W. L., *Can. J. Bot.*, **30**, 209 (1952).

Microflora of Crêpe Rubber

Comparatively little is known about the microfungi normally present on the surface of native *crêpe* rubber. Brown[1] isolated two chromogenic penicillia and a *Fusarium* from discoloured areas of spotted *crêpe*. Fullerton[2] attributed the spotting of smoked sheet and *crêpe* to species of *Aspergillus*, *Penicillium*, *Fusarium* and unidentified bacteria. Schade[3] obtained *Monascus ruber* and *M. purpureus* from smoked sheet. More recently, Shaposhnikov *et al.*[4] isolated four species of *Aspergillus* and three species of *Penicillium* from smoked sheet, and obtained vigorous growth from inoculations with other common surface moulds.

As a part of a programme of research on the application of bactericides and fungicides to raw and vulcanized rubbers, initiated by the Rubber Service Laboratories of I.C.I., Ltd., in collaboration with ourselves, samples of discoloured *crêpe*, obtained from Ceylon[5], were incubated in moist chambers at 25° C., and the resulting colonies of fungi were subcultured on 2 per cent malt agar until pure cultures of each infecting species were obtained. The pure cultures were grown on 2 per cent malt and Czapek–Dox agars and on pieces of *crêpe* rubber sterilized by steam or methyl alcohol vapour. The species isolated and their behaviour on subculture are listed in the accompanying table.

Fungi isolated from *Crêpe* Rubber

Original discoloration	Micro-organisms isolated from discoloured area	Colour on malt agar	Discoloration of inoculated *crêpe*
Black	*Cladosporium herbarum* (Persoon) Link	black	black
Blue-black	*Helminthosporium* sp.	black	black
	Syncephalastrum sp.	grey	grey
	Penicillium islandicum Sopp	red	brown
	Black pycnidia (unident.)	black	—
Brown	*Penicillium chermesinum* Biourge	red	brown
Yellow-brown	*Margarinomyces luteo-viridis* van Beyma	black	black
Orange	*Bacillus subtilis* Cohn	—	—
	Penicillium citrinum Thom	yellow	yellow
	Penicillium variabile Sopp	orange	brown-pink
Red	*Penicillium purpurogenum* Stoll	red	red
Violet	—	—	—
Green	—	—	—

Repeated culture of the green- and violet-stained rubbers produced no fungal growth; unidentified bacteria were isolated from the violet-stained rubber. The commonest infection was from *Penicillia*, particularly the species *variabile*, *chermesinum* and *citrinum*. Several strains of *P. citrinum* were isolated of varying chromogenic power. Red stains apparently due to *P. purpurogenum* occurred with some frequency; *P. islandicum* was found on a single culture only.

The species of *Penicillium* present on the rubbers are recorded as common in tropical and subtropical areas, and have been isolated in these areas from deteriorating military equipment.

The wide variety of infecting organisms confirms the views of Shaposhnikov *et al.* that unvulcanized rubbers can support the growth of most common microfungi and that infection is airborne during the drying of the *crêpe* sheet.

Thanks are due to the Rubber Research Institute of Ceylon, which provided the samples of discoloured *crêpe* for examination.

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[1] Brown, W., *Bull. Rubb. Growers' Assoc.*, **6**, 632 (1924).
[2] Fullerton, R. G., *Quart. J. Rubb. Res. Inst. Malaya*, **1**, 66 (1929).
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Poetry and Science

If the report in *Nature* of January 16 of the discussion at the Penn Club on "Poetry and Science" is accurate, some interesting confusions seem to have arisen. We are told that poets and scientists were antagonistic in the past, because they were under the mistaken impression that there was a real external world—so Prof. H. Dingle. Stephen Spender demanded the right to a subjective knowledge of truth—as if 'knowing' could ever be wholly objective. G. S. Fraser insisted that poetry has its own criteria of exactness—which no scientist could possibly dispute. Mr. N. W. Pirie is reported to have said that scientists discard statements they dislike—surely with some indication of the criteria which, if not satisfied, arouse his dislike.

It must be obvious that both poet and scientist have their own disciplines for exploring human reactions to the world they live in, that these disciplines can be studied, and a methodology of science and of poetry worked out and compared, and seen in their complementary aspects. One gained the impression, from the report, of a confused battle between the Subjectives and the Objectives with Prof. Dingle above the storm, content to know that the battle was taking place in a non-existent universe. That unreality is, at any rate, some consolation to those of us who try to live rationally in this world.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 15

SOCIETY OF CHEMICAL INDUSTRY, CROP PROTECTION PANEL of the AGRICULTURE GROUP (in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. R. L. Wain: "Some Recent Developments in the Field of Plant Growth Substances".

UNIVERSITY OF LONDON (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. J. M. Bijvoet (Utrecht): "The Structure of Optically Active Compounds in the Solid State: and some other Problems". (Further Lectures on March 17 and 19.)*

INSTITUTE of METAL FINISHING (in Room 153, Connaught Building, Northampton Polytechnic, St. John Street, London, E.C.1), at 6 p.m.—Mr. P. Spiro: "Recent Developments Concerning Electroforming of Moulds".

BRITISH SOCIOLOGICAL ASSOCIATION (at the Royal Society of Arts, 6 John Adam Street, Adelphi, London, W.C.2), at 8 p.m.—Mr. Tom Harrisson: "Bolton and Borneo—15 Years of 'Overheads' ".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Lieut.-Colonel Sir Rupert Hay: "The Persian Gulf States and Their Boundary Problems".

Tuesday, March 16

UNIVERSITY OF LONDON (in the Anatomy Theatre, Communication Research Centre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. D. B. Fry: "The Experimental Study of Speech".*

BRITISH ORNITHOLOGISTS' UNION (in the Meeting Room of the Offices of the Zoological Society of London, Regent's Park, London, N.W.1), at 6 p.m.—Annual General Meeting.

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. F. H. Carey: "The Development of the Spill Flow Burner and its Control System for Gas Turbine Engines".

SHEFFIELD METALLURGICAL ASSOCIATION (joint meeting with the REFRACTORIES ASSOCIATION OF GREAT BRITAIN and the INSTITUTE OF CLAY TECHNOLOGY, at the Grand Hotel, Sheffield), at 7.30 p.m.—Dr. A. T. Green: "Dr. Mellor—His Life and Work".

Wednesday, March 17

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. E. D. Adrian, O.M., F.R.S.: "Recent Developments in the Study of the Sense Organs" (Trueman Wood Lecture).

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. A. Kingsley Wells and Mr. A. Clive Bishop: "An Appinitic Facies Associated with Certain Granites in Jersey, Channel Islands"; Dr. J. D. Lawson: "The Geology of the May Hill Inlier".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.*

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY, SOCIAL PHILOSOPHY SECTION (in the Portico Library, 57 Mosley Street, Manchester 2), at 5.30 p.m.—Discussion on "Social Problems of the Welfare State".

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (at the Science Museum, South Kensington, London, S.W.7), at 5.30 p.m.—Symposium on "Hydrogen Liquefaction".

Thursday, March 18

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Prof. L. S. Hearnshaw: "Attitudes to Work" (Chairman's Address).

PHYSICAL SOCIETY, OPTICAL GROUP (in the Physics Department, Imperial College, Imperial Institute Road, South Kensington, London, S.W.7), at 2.30 p.m.—Annual General Meeting. Mr. W. N. Sproson: "A New Photo-electrical Optical Test Bench"; Mr. L. C. Jesty: "Recent Developments in Colour Television".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (at the Chemical Research Laboratory, Coleshill Road, Teddington, Middlesex), at 2.30 p.m.—Scientific Papers.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Meeting for Election of Fellows. 4.30 p.m.—Mr. F. P. Bowden, F.R.S., and Mr. P. H. Thomas: "The Surface Temperature of Sliding Solids"; Mr. R. F. King and Mr. D. Tabor: "The Strength Properties and Frictional Behaviour of Brittle Solids".

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. G. Chad Norris: "Some Grinding Tests with Spheres and Other Shapes"; Mr. G. Lowrie Fairs: "A Method of Predicting the Performance of Commercial Mills in the Fine Grinding of Brittle Materials".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. G. Hawkes: "Taxonomic Studies on the Tuber-bearing Solanum".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. F. F. Bonsall: "Endomorphisms of Partially Ordered Vector Spaces".

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDINGS MATERIALS GROUP (in the Lecture Hall, Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1), at 6 p.m.—Mr. C. van der Poel (Amsterdam): "A General System Describing the Visco-elastic Properties of Bitumens and their Relation to Routine Test Data".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.30 p.m.—Sir Christopher Hinton: "Atomic Energy Made Easy".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at the Royal Army Medical College, Millbank, London, S.W.1), at 7.30 p.m.—Laboratory Meeting. Chairman: Dr. F. Norman White.

Thursday, March 18—Friday, March 19

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING AND FOOD GROUPS (at the Wellcome Research Institution, 183 Euston Road, London, N.W.1), at 10 a.m. daily.—Conference on "Chemical Engineering in the Food Industry".

Friday, March 19

SOCIETY FOR WATER TREATMENT AND EXAMINATION (in the Library of the Water Examination Department, Metropolitan Water Board, Rosebery Avenue, London, E.C.1), at 9.30 a.m.—Annual General Meeting, followed by Scientific Papers.

INSTITUTE OF PETROLEUM (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 2.15 p.m.—Symposium on "Metal-Working Oils".*

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Annual General Meeting.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. N. Pevsner: "Sir Christopher Wren".

Saturday, March 20

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, SCIENTIFIC AND TECHNICAL GROUP (in the Clarendon Laboratories, Oxford).—Whole Day Conference on "Photochemistry and Photography".

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, University College, Gower Street, London, W.C.1), at 10.45 a.m.—Annual General Meeting, followed by the reading of Scientific Papers.

BRITISH PSYCHOLOGICAL SOCIETY (in the Psychology Department, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. W. Mays: "Piaget's Genetic Theory of Concept Formation".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PHYSICISTS and ENGINEERS, Scientific Officer, Experimental Officer, or Assistant Experimental grades, at the Ministry of Supply Experimental Establishment, near Salisbury, Wilts—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.45/54A (March 20).

LECTURER IN PHYSICS—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (March 22).

SCIENTIFIC OFFICER, Grade 3 (with a degree in mechanical or aeronautical engineering, or equivalent qualifications, together with experience in the conduct of aerodynamic investigations, preferably of supersonic flight), at the Long Range Weapons Establishment, Salisbury, South Australia, to undertake investigations of an aerodynamic nature concerning supersonic guided missiles—The Senior Representative (A.P.7), Department of Supply, Australia House, Strand, London, W.C.2 (March 22).

SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with first- or second-class honours degree or equivalent qualification in physics, chemistry or metallurgy) for development work on carbon for nuclear reactors, involving structural studies of porous solids—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Berkshire (March 22).

ASSISTANT LECTURERS IN BOTANY (preferably with special qualifications in microbiology), ORGANIC CHEMISTRY, PURE MATHEMATICS, PSYCHOLOGY and ZOOLOGY—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (March 26).

LECTURER (with special qualifications and experience in the field of vocational selection, guidance and training) IN THE DEPARTMENT OF PSYCHOLOGY, to be responsible for vocational courses leading to a newly established postgraduate Diploma in Applied Psychology—The Registrar, The University, Liverpool (March 26).

ASSISTANT OFFICIAL ANALYST (with at least an honours degree in chemistry, or the A.R.I.C. Diploma, and preferably with a knowledge of French)—The Greffier of the States, States' Greffe, Jersey, Channel Islands (March 31).

LECTURER IN AGRICULTURAL BOTANY—The Secretary of University Court, The University, Glasgow (March 31).

LECTURER (with an honours degree in petroleum production engineering, chemical engineering, mechanical engineering, or geology, with postgraduate or industrial experience in engineering) IN PETROLEUM PRODUCTION ENGINEERING, in the Chemical Engineering Department—The Registrar, The University, Edgbaston, Birmingham (March 31).

SCIENTIST (with first- or good second-class honours degree or equivalent in physics, engineering, mathematics or statistics, and several years industrial or laboratory research experience) IN THE FIELD INVESTIGATION GROUP, Scientific Department, to lead a team carrying out field work at collieries—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/750 (April 3).

SENIOR LECTURER IN AGRICULTURAL ECONOMY at the University College of the Gold Coast—The Secretary, Inter-University Council, 1 Gordon Square, London, W.C.1 (April 3).

SENIOR LECTURER IN THE TEACHING OF PHYSICAL SCIENCE—The Secretary, University of London Institute of Education, Malet Street, London, W.C.1 (April 10).